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FUTURE MEETINGS

of the

American Institute of Electrical Engineers

Place	*Date*	*Nature*	*Latest Date for Receipt of Manuscripts*
New York, N. Y.	Jan. 25-29, 1932	Winter Convention	(Closed)
Milwaukee, Wis.	March 14-16, 1932	District Meeting	Dec. 14, 1931
Providence, R. I.	May 4-7, 1932	District Meeting	Feb. 4, 1932
Cleveland, Ohio	June 20-24, 1932	Summer Convention	March 20, 1932
Vancouver, B. C.	Aug. 29-Sept. 2, 1932	Pacific Coast Convention	May 29, 1932
Baltimore, Md.	October-1932	District Meeting	July-1932
Memphis, Tenn.	November-1932	District Meeting	August-1932

NOTE: Members who are contemplating submitting papers for presentation at any of the above meetings should communicate promptly with Institute headquarters, 33 West 39th Street, New York, N. Y., so that their papers may be docketed for consideration by the technical program committee, which formulates programs for all meetings several months in advance. Upon receipt of this notification, Institute headquarters will mail to each prospective author information in regard to the Institute's rules relating to the preparation of manuscript and illustrations.

MEETINGS OF OTHER SOCIETIES

AMERICAN PHYSICAL SOCIETY, regular Pacific Coast meeting, Berkeley, Calif., December 18-19, 1931; annual meeting, New Orleans, La., December 29-30, 1931. (W. L. Severinghaus, secretary, Columbia University, New York, N. Y.)

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, annual meeting, New Orleans, La., January 2, 1932. (Chas. F. Roos, secretary, Smithsonian Institution, Washington, D. C.)

AMERICAN ENGINEERING COUNCIL, Washington, D. C., January 14-16, 1932. (L. W. Wallace, 744 Jackson Place, N. W., Washington, D. C.)

NORTH CENTRAL ELECTRIC ASSOCIATION, Engineering Section, St. Paul Hotel, St. Paul, Minn., February 22-23, 1932. (J. W. Lapham, 803 Plymouth Building, Minneapolis, Minn.)

SOUTH AMERICAN ELECTROTECHNICAL CONGRESS, Buenos Aires, July 4-11, 1932. (R. F. Ascher, general secretary, Paseo Colon 185, Buenos Aires, S. A.)

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This Month—

Front Cover

Diablo Dam, one of the three major units of the Seattle (Wash.) municipal hydroelectric development on the Skagit River. This dam is 386 ft. high and 1,200 ft. long at the crest; it will supply a plant having a proposed capacity of about 320,000 hp. at a gross head of about 330 ft.

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Abstracts of Institute Papers—

Short Item—

News of Institute and Related Activities . . 971

DO YOU wish your twelve 1931 copies of ELECTRICAL ENGINEERING bound for permanent record purposes? *(See p. 18 advertising section.)* subscriber if requested before January 15, 1932. (See announcement, *p. 22 advertising section;* order form, *p. 992.*)

ANNUAL index to ELECTRICAL ENGINEERING for 1931 is being published in separate pamphlet form; a copy is available without charge to each member or

DR. M. I. PUPIN, one of the Institute's nine living Honorary Members, introduces an exact theory of inductive balancing networks for submarine telegraph cables. *(See p. 933-6.)*

A NEW scheme is proposed for reading watthour meters over telephone lines. *(See p. 942-4.)*

RESEARCH in dielectrics has witnessed an unusual intensity during the past year in the study of insulating liquids. *(See p. 967-70.)*

UNUSUALLY active participation by Enrolled Students was but one of the noteworthy features of the recent Kansas City district meeting reported in full in this issue. *(See p. 973-5.)*

THAT engineers will "share generously" is evidenced by the plans already under way for participation by the Institute's Sections in the organization of local engineers' unemployment relief committees. *(See p. 975.)*

FOURTEEN technical sessions, interesting inspection trips, and special entertainment features, represent the principal attractions of the forthcoming winter convention, plans for which rapidly are assuming final form. *(See p. 971-2.)*

PROCESSES involved in the extinguishing of the short a-c. arc, as encountered in circuit interrupters and in low voltage power distribution networks, have been subjected to rather close scrutiny in a group of three articles. *(See p. 948-57.)*

IN THIS month's article of the Engineering Foundation series "Has Man Benefited by Engineering Progress?" it is stated that "the growth of understanding by the many will form the foundation for a new and greater progress." *(See p. 947.)*

UNFORTUNATE rotor and stator slot combinations in induction motors often cause serious irregularities in their operating characteristics. Some of the many angles of this perplexing situation are reviewed in a group of three articles. *(See p. 936-42.)*

THOSE concerned with the operation of electric power cables are referred to (1) a simple method of calculating cable temperatures under variable loads *(see p. 944-6)* and (2) methods for calculating sheath losses due to the proximity of electric power currents *(see p. 965-6)*.

Nerve Injuries From Electric Shock

During the last few years the authors have been studying the effect of electricity upon the nervous systems of experimental animals. In this article are discussed briefly the types of changes found in the brain, the spinal cord, and in the nerve cells themselves following an electric shock.

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O. R. LANGWORTHY
Non-member

Both of
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LABORATORY experiments made at The Johns Hopkins University to determine the effect of electric shock upon living animal organisms now have reached a considerable total, and well may be divided into groups according to the specific question being studied upon the occasion of the various groups of tests. This classification is indicated in the accompanying bibliography to which the numbered references apply. The scope of the article[6] which appeared in the June 1931 issue of ELECTRICAL ENGINEERING was limited to a comparison of the final results as they affected the physical well-being of the subject of the experiment, the article in effect being supplementary to one previously published.[1] It is the aim of the present article to describe and discuss briefly the results observed by microscopic study of the central nervous system in specimens subjected to shock according to experiments previously reported. The actual changes following an electric shock as found in the brain, spinal cord, and the nerve cells themselves are outlined.

Because of their convenient size and because a rat's heart is not easily damaged by electric current these animals were used as the experimental subjects in all cases, thus making it possible to focus the attention upon the nervous system. In each case the rat was given ether before the shock was applied. Directly after death the brains and spinal cord of each rat were removed and immediately "fixed" in suitable solutions to avoid postmortem changes. This material was sliced and examined, first with the unaided eye, and later microscopically to permit a detailed study of the nerve cells. However, only a part of the material subjected to this microscopic study was derived from the experimental subjects; the nervous systems of two electrocuted men also were examined.[5]

In the first series[1,2] a number of animals were studied after being subjected to a-c. or d-c. shocks of 110, 220, 500, or 1,000 volts. The time of contact varied in each group. In that series the electrodes were applied to the top of the skull and the base of the tail. For the 110- and 220-volt circuits more serious injuries resulted from a-c. than from d-c. shock, while with a circuit potential of 500 volts, the effects of a-c. and d-c. shock were approximately equal. For circuit potentials of 1,000 volts it was clear that the d-c. shock produced a greater injury than the a-c. shock, particularly when the time of application was taken into consideration.

For the different potentials of both alternating and continuous current, rather definite characteristic abnormalities[3,4] were found in each group shocked. The d-c. shocks more often produced symptoms of irritation to the nervous system, such as convulsions, whereas many of the rats receiving a-c. shocks showed paralysis of the posterior portion of the body directly after the shock. These paralyzed animals were quiet, would not eat, and never lived longer than two or three days. These latter cases when studied after death showed an abnormally soft spinal cord; and microscopic observation of cross-sections of the cords revealed that an area of hemorrhage, extending over a relatively long portion of the cord, had severed nervous pathways. In all cases the great majority of hemorrhages in the spinal cord occurred in the areas indicated in Fig. 1, although of course some were found in other places. Similar hemorrhages but usually smaller, occurred in the region of the brain. When these existed in the region controlling respiration, they were considered responsible for the death of the animal. In some cases hemorrhages were present also in the tissues covering the brain.

In the cases of experimental animals it may be said of hemorrhages that: (1) in the nervous system they are responsible for the immediate or subsequent death of a certain group subjected to contacts with electric circuits; (2) they are much more common after contact with a-c. circuits than after contact with d-c. circuits; and (3) they increase in number with the increase of circuit potential. Hemorrhages have been found also in the brains of men who have died as the result of similar shocks. Such hemorrhages probably are caused

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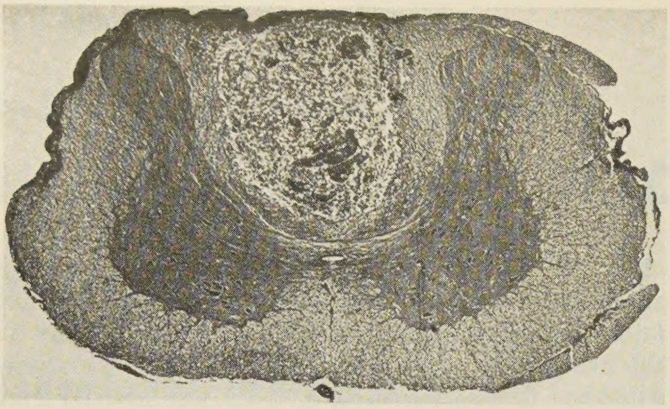

Fig. 1. Cross-section of the spinal cord of a rat

The hemorrhage which may be noted in the upper and central portions is typical of the effect which caused paralysis of the hind legs and subsequent death of the animals

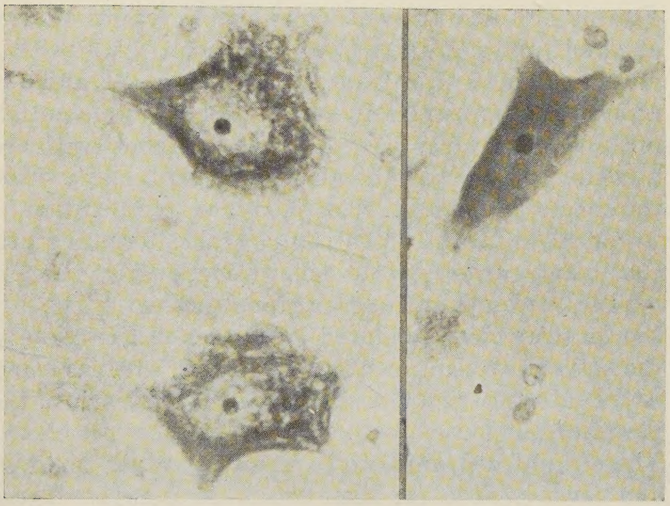

Fig. 2. Two normal nerve cells and one damaged nerve cell

LEFT—The clear area at the center is the cell nucleus; the dark dot is the nucleolus. The remainder of the cell is filled with deep-staining, flaky granules. RIGHT—A brain cell from a rat injured by contact with an a-c. circuit. It may be noted that the nerve cell is shrunken, darkly stained, and that no distinct granules are to be seen

by the sharp rise of blood pressure which follows the breaking of the contact with an electric circuit.

During the period of current flow, the blood collects in the veins, being squeezed from the heart and arteries by the contraction of the muscles in their walls. When the heart resumes its beating all this blood is forced back at once into the heart and arteries often overtaxing the capacity of the arteries and resulting in ruptures in their walls. With either a-c. or d-c. 1,000-volt circuits, severe burns often occurred around the electrode, in some cases resulting in an erosion of the skull beneath the head electrode and even burning the surface of the brain itself. (This would be a rare type of injury in man inasmuch as the head seldom lies in the direct pathway of the current.) Generally the burns from contact with a 1,000-volt d-c. circuit were found to be more severe than those from a 1,000-volt a-c. circuit.

In this group of rats where the current passed through the head, changes in the nerve cells could be demonstrated even when animals died at once following the shock. After shocks at 500 and 1,000 volts these changes were more marked than after the lower voltage, as might be expected. In addition, they were more severe as a result of d-c. shocks than with a-c. shocks. Nerve cell damage is illustrated in several of the accompanying photomicrographic reproductions.

In making these photomicrographic studies, the finer cell structures are differentiated by staining the cells with a basic aniline dye. Certain portions of the cell have an affinity for basic dyes; others for acid dyes. In Fig. 2 the left-hand illustration shows normal nerve cells stained with an aniline dye demonstrating the characteristic granular structure of the cell. The cell edges are not regular, but are prolonged outward into angles which form the origin of nerve fibers. The clear area which always lies in the center of normal cells represents the nucleus, and near its center contains a black dot which is known as the nucleolus. Around the nucleus there are fluffy deep-staining granules which fill the remainder of the cell, always arranged in this characteristic manner with the type of cells represented in the illustrations. The granules probably are formed after death by the coagulation of some protein substance. Nerve cells injured by the passage of an electric current through the body, some from the brains of rats and others from human material, are reproduced in Figs. 2, 3 and 4.

Experience shows that all nerve cells even in a given group do not show an equal amount of damage as the result of an electric shock, several normal cells often being found among others that have suffered great changes. Extensive microscopic studies support the belief that cells having the potentialities of recovery may be differentiated from those rendered completely and permanently functionless. In this connection the nucleus is the real index of the ultimate fate of the cell; if it shows marked damage the cell will die. In the case of experimental animals that recovered from the immediate effects of shock and were killed three or four days later, the nerve cell changes could be demonstrated with even greater clarity than in those animals which did not survive the shock. There appeared to be many cells which were permanently damaged, and others having the potentialities of recovery.

When a man suffers an electric shock which stops his breathing, artificial respiration should be continued for a prolonged period in order to give the nerve cells controlling respiration time to recover their normal functioning. Of course in the cases where changes in the nerve cells are extremely severe, recovery naturally cannot be expected, but since this cannot be predeter

mined the only safe and logical course is long-continued resuscitative effort.

Another question which arose had to do with the probability of injury to nerve cells when those cells did not lie in the direct path of the current. To test this question [6,7] the electrodes were shifted from one portion of the body of the experimental subject to another, and either a-c. or d-c. shocks at 1,000 volts were applied for one second. These resultant experimental findings demonstrated clearly that such contact caused damage to nerve cells only in that portion of the nervous system traversed by the current. Of course a current traversing the chest may produce serious changes in nerves controlling breathing and this injury of the nerve fibers is reflected in the cells from which they arise. It has been shown that electricity may produce a temporary block to nerve fibers as well as in nerve cells.

It is of importance to note that the type of changes produced in nerve cells by electric shocks are nonspecific and may be caused by other physical and toxic agents. Very high bodily temperature may damage nerve cells, and it is an established fact that body temperature rises rapidly in the case of electric shock if the circuit is closed for any length of time. This is supported by the results of autopsy performed on a man who suffered accidental death by contact with a 2.2-kv. 60-cycle circuit. The contact was from one arm to one leg, lasted several minutes, and badly burned the body. In this case the brain cells showed marked changes, even though that region did not lie in the direct pathway of the current. Therefore it must be considered, that if the body temperature is elevated to a considerable degree, changes everywhere in the delicate nerve cells must be expected. These changes are indistinguishable from those produced by electricity alone.

To eliminate heat as a source of nerve cell damage, several experiments were conducted using a small impulse generator[8] as the source of the electric shock. Circuit constants were so chosen that the entire duration of the surge did not exceed 4.5 microseconds, while the maximum current was about 100 amperes and the potential, 200 kv. The small amount of energy involved, coupled with the extremely short duration of the surge, produced little or no temperature rise in the animals subjected to the test. These rats were oriented in different ways with respect to the electric discharge so as to obtain results from current passage through different portions of the body. Marked changes in the nerve cells themselves were found in the brain and spinal cord of the subjects when it was traversed directly by the surge current. It is clear therefore that an electric discharge produces profound changes in nerve cells, even in cases where heating is not a possible factor. When the period of contact is prolonged, heat undoubtedly produces marked alterations.

In addition to heat there is another cause which affects nerve cells lying outside the current path. Where, for example, the contacts are at points on the same arm or leg, the passage of the electric current between these points gives rise to violent impulses which the peripheral nerves transmit to the brain. When these impulses are very strong they may produce a condition of shock akin to that perceptible after operations and fractures. This, the authors believe, is the explanation of death which occurred in several of the rats, following the passage of an electric current from hind leg to hind leg.

Injury to the nervous system resulting from electric shock has been studied recently by Morrison, Weeks, and Cobb[9] working independent of the present

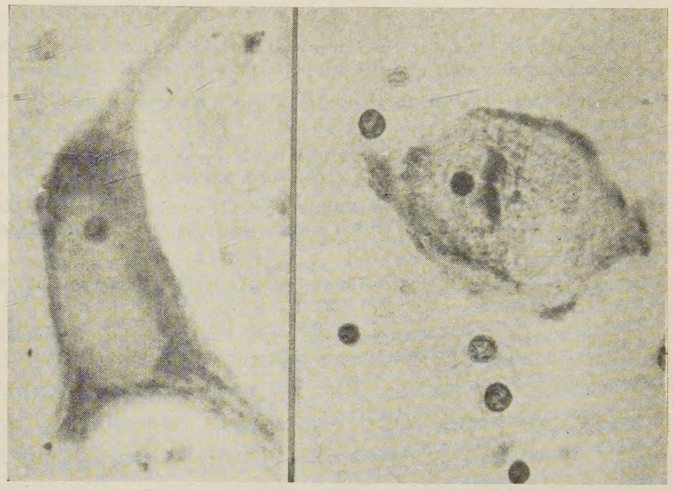

Fig. 3. Two damaged human nerve cells

RIGHT—From the brain of a man killed by a prolonged contact with a 2.2-kv. a-c. circuit. The edge of the nucleus may be noted to be irregular and to stain darker than normal; its nucleolus is swollen. There are few granules remaining in the cell. LEFT—From the brain of a legally executed twenty-four year old man. It may be noted that the nucleus edges are indistinct, the nucleolus swollen, and that there has been a loss of granules from the center of the cell

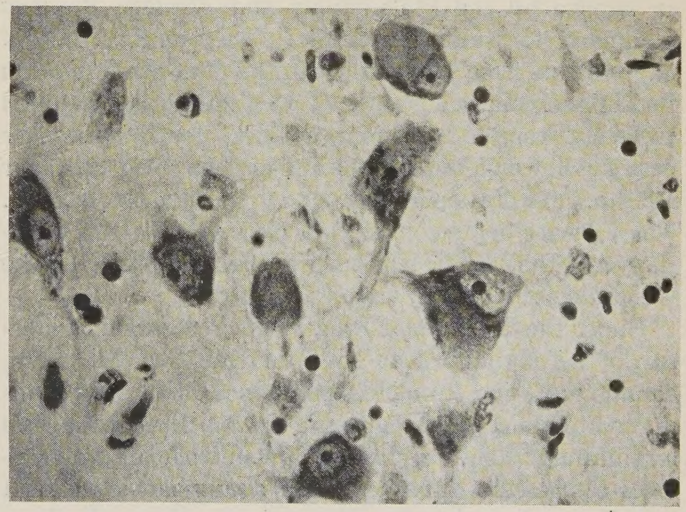

Fig. 4. Damaged human nerve cells

A group of cells from the nerve center controlling breathing, from the brain of a man killed by contact with a 2.2-kv. circuit. It may be noted that the nucleus is pushed to one side of the cell and that there are but few granules

authors. Their findings agree well with those reported in this article.

The authors wish to take this opportunity to acknowledge the support given to this work by the committee on physiology of the conference on electric shocks.

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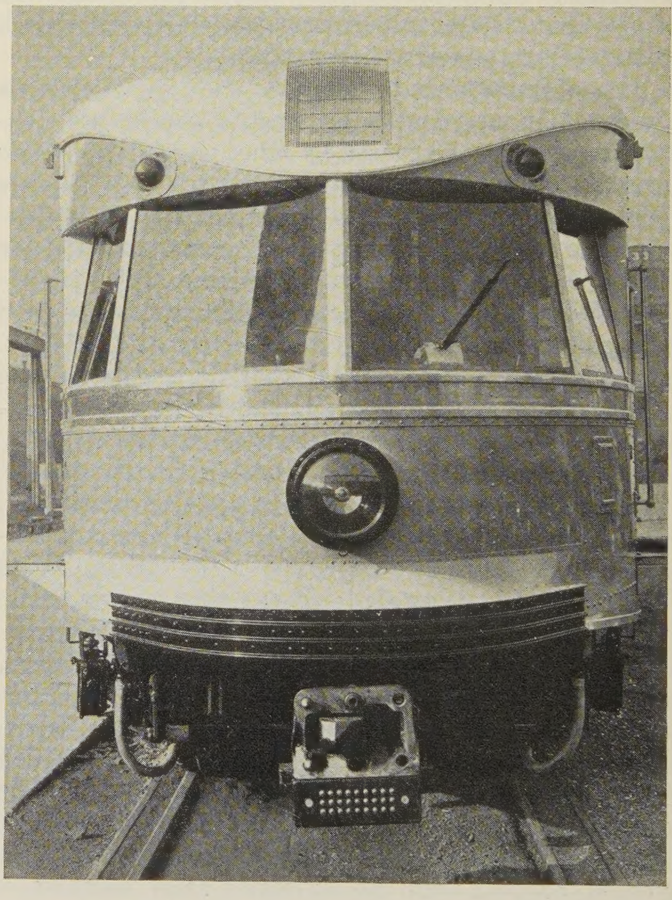
New Interurban Cars Secure High Speed at Low Cost

TEN STREAM-LINE aluminum-body cars capable of a speed of 80 miles per hr. are being placed in service by the Philadelphia and Western Railway Company for suburban traffic. The running time of express cars from Norristown to the 69th Street station in Philadelphia, a distance of 13½ miles, is scheduled to be cut from 24 to 16 min. by these new 52-passenger cars which weigh but 25 tons and are equipped with four 100-hp. motors operating under automatic control. The cars are being constructed by the J. G. Brill Company and the electric equipment is being supplied by the General Electric Company.

Under the direction of Prof. F. W. Pawlowski, professor of aerodynamics at the University of Michigan, exhaustive wind tunnel experiments have been conducted to assist the designers in cutting air resistance to a minimum. The windows are flush with the side surfaces of the cars, the under-floor equipment is planned to reduce air resistance, the cars, on the underslung principle, have a low center of gravity, the roof is relatively low, and each end of the car has a sloping roof and pointed nose. The entire body is aluminum, with a polished aluminum "belt rail" and "skirt" running from end to end below the windows, adding greatly to appearances. Wind-tunnel tests showed that with the conventional cars operating between 70 and 80 miles per hr. more than 70 per cent of the total power is consumed in overcoming air resistance. The stream-line design of these new cars will save approximately 20 per cent of the power required to propel them at speeds above 60 miles per hr.

The weight per horsepower of the 600-volt motors has been reduced from the usual value of 30 or 35 lb. per hp. to 26.8 lb. per hp. This has been accomplished by the use of fabricated gear cases, cast-steel semi-fabricated frame heads, and modifications of motor frame design. Self-ventilation of the motors has been improved by the use of a fan mounted on the commutator end of the shaft. With the motor control system employed, starting currents are held automatically to the highest permissible values consistent with good commutation; thus every acceleration is the maximum which can be obtained successfully. This new type of high speed, light weight car providing fast and comfortable service is expected to result in increased patronage, higher schedule speed with lower platform costs, lower maintenance costs, and a saving in power consumption.



Front view of one of the new high-speed stream-line cars soon to be placed into service by the Philadelphia and Western Railway Company

Balancing Cables by Inductive Networks

Greater transmitting speeds are possible in submarine telegraph cables when balanced by inductive networks than could be obtained with the older resistance networks. In this article is presented the first exact theory of inductive balances of which two already are in successful practical operation.

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ELECTRICAL BALANCING of submarine cables by a network of conductors for purposes of duplex telegraphy is an old art. As long as these cables had a fairly high resistance, as they did in earlier years, their signaling speed was necessarily low. Under these conditions a satisfactory balancing network, the well known artificial line, consisted of resistances connected in series, and capacitances connected from ground to each junction of two consecutive resistances. This network was the equivalent of a sectional conductor, each section having resistance and capacitance, but no inductance; electrical reactions of the network imitated the electrical reactions of the cable. At low signaling speed such a network gave satisfactory results when its sections were sufficiently small and when a sufficiently large number of sections was used.

In recent years long submarine telegraph cables of low resistance have been laid for the purpose of increasing the speed of signaling. The heavy cable laid eight years ago by the Commercial Cable Company between Canso, Nova Scotia, and the Azores has a resistance of only about one ohm per nautical mile; it was intended to transmit at the rate of 600 letters per minute. At this speed, however, the inductance reaction of the cable came into play and the old balancing network containing no inductance in its sections could not balance it. In duplex working this heavy cable had to be operated at a much lower speed to accommodate the non-inductive balancing network. The design of an efficient inductive network thus became a very important problem in the operations of this long low-resistance cable.

Written especially for Electrical Engineering. *Not published in pamphlet form.*

Earlier Inductive Networks

Even a superficial study of this problem made obvious the fact that the old balancing artificial line had to be changed by introducing in its sections suitable inductive elements in place of the simple resistances. It was obvious also that within a certain frequency interval the effective inductance and resistance of these elements must vary with frequency, simulating the variations of effective inductance and resistance of the corresponding sections of submarine telegraph cable which was to be balanced. This seemed to introduce into the problem an insurmountable difficulty.

Breisig (*Electrotechnische Zeitschrift,* November 1899) and, twenty years later, Pernot (*Journal Franklin Institute,* September 1920; *British Patent Specification,* 1922) discovered that the effective inductance and resistance of a submarine cable section vary with frequency somewhat like the effective inductance and resistance of the primary of a transformer with its secondary short circuited. This discovery led to several attempts to imitate in the balancing network the electrical reactions of a cable by inserting in the sections of the old artificial line, transformers with short-circuited secondaries or their equivalent, that is, inductance short circuited by a non-inductive resistance or by another inductance. The most noteworthy among these attempts were those of Murihead Company and Davis (*British Patent Specification* 216, 219, March 24, 1924) and of Gilbert (*U. S. Patent,* 1,533,178, April 1925). No results ever have been published

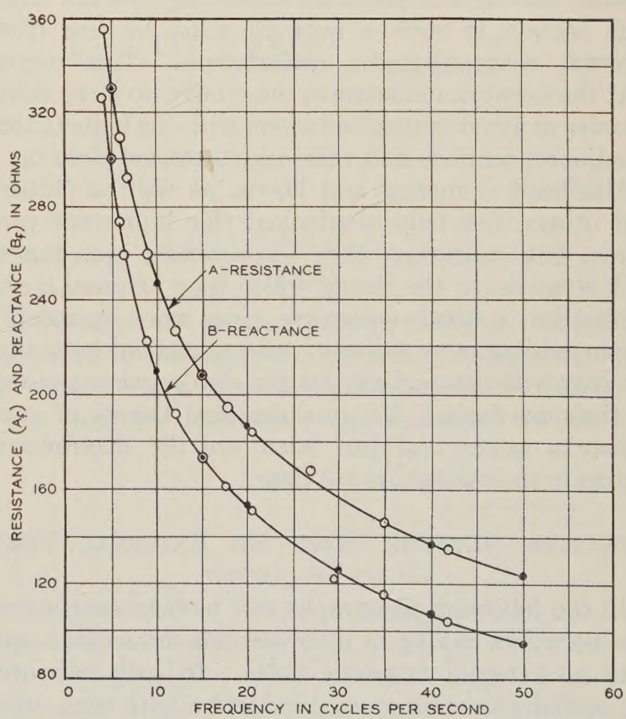

Fig. 1. Effective terminal resistance (A) and reactance (B) for a typical submarine telegraph cable (circles) and for the inductive network designed to balance it (dots)

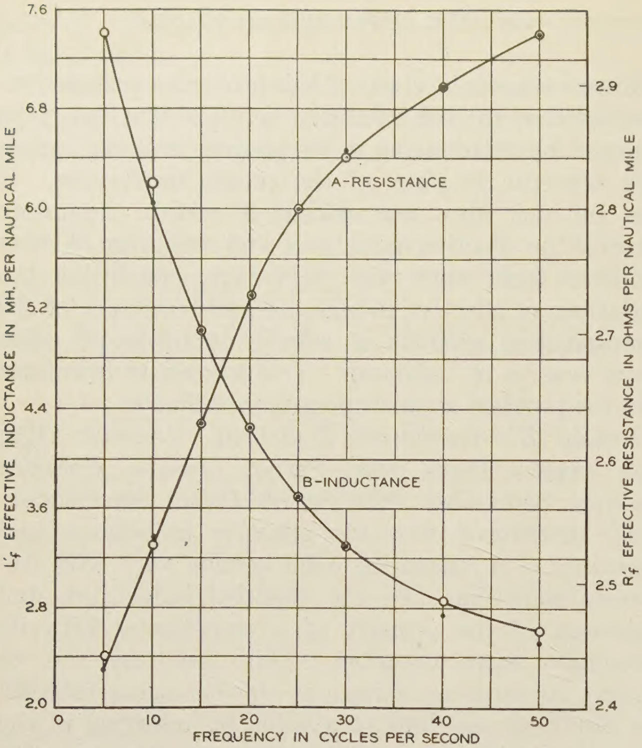

Fig. 2. Effective resistance (A) and inductance (B) per nautical mile for "equivalent" cable (circles) and for the network designed to balance it (dots)

which show how these applications of the old ideas of Breisig and Pernot succeeded in practise. It will be shown presently, however, that these applications cannot lead to a satisfactory balancing network since each section in such a network must be free from external electromagnetic disturbances. This means that the network inductances must have no stray fields in order to avoid mutual induction with the inductances in adjacent sections and with other external circuits.

Murihead Company and Davis, as well as Gilbert and others, not only overlooked this important provision, but, moreover, they *recommended* inductances with stray fields; the theory which they followed is not applicable to their structures since they invariably employed inductive elements having mutual induction not only with external circuits but also between sections of their networks. No mathematical theory of such networks exists, and just what are the determining factors in their design, is not clear.

Inductive Network With No External Field

In the following paragraphs will be discussed inductive networks having in their sections inductance coils with no external magnetic fields. In such networks the sections have no mutual induction with each other nor with external circuits; they are, therefore, free from external electromagnetic disturbances.

In a submarine cable which already is laid, the only quantities that can be measured are its terminal reactance and resistance at various frequencies. These measurements were made on a typical cable and formed the foundation of the study discussed here.

Curves A and B of Fig. 1 represent at various frequencies the effective terminal resistance a_f and the effective terminal reactance b_f of a cable as determined by wheatstone bridge measurements. The cable is one belonging to the Commercial Cable Company and connects Far Rockaway, Long Island, with Canso, Nova Scotia. Its constants are

Length . . . . l = 974.33 nautical miles
Average capacity . . . . . c = 0.384 μf. per nautical mile
Average copper resistance . . . . r = 2.45 ohms per nautical mile

Submarine cables are not of the same size at each point in their length; shore ends are much larger than deep sea parts, and hence the effective capacity and the effective inductance vary from point to point. The cable just referred to thus is not uniform, but a uniform cable which at all frequencies will have the same terminal reactance and resistance as this cable can be designated in theoretical studies; call it the *equivalent cable.* It can be specified as follows: Let C_f', R_f', and L_f' be the capacity, resistance, and inductance respectively per unit length of this equivalent cable at frequency f. Then if it is to have the same terminal reactances and resistances at various frequencies as those recorded in Fig. 1

$$a_f - i\, b_f = \sqrt{\frac{L_f'}{C_f'} - \frac{i\, R_f'}{p\, C_f'}}$$

or

$$(a_f^2 - b_f^2)\, C_f' = L_f'; \quad 2\, p\, a_f\, b_f\, C_f' = R_f' \qquad (1)$$

where $p = 2\,\pi\, f$

Make C_f' independent of the frequency and equal to 0.384 μ f., the same as the average capacity per unit length of the Far Rockaway-Canso cable. From eqs. 1 and curves A and B of Fig. 1, the effective resistances R_f' and inductances L_f' of the equivalent cable were calculated. From these calculations curves A and B of Fig. 2 were plotted for the frequency interval between 5 and 50 cycles per second.

An inductive network which can balance this equivalent cable obviously will balance also the original cable. Such a network will balance the equivalent cable at every frequency for which the effective inductance and resistance in its sections are the same as in the corresponding lengths of the cable. The aim of this study was to design a balancing network of this kind, employing in its sections inductance coils possessing no external fields. Several methods of construction were found to give very satisfactory results. The simplest of these is described here in some detail.

Network of Inductances in Series

The network discussed here employs in each of its sections two inductance coils connected in series as

shown by coils 3 and 4 of Fig. 3. Each coil is toroidal in shape and thus has no external magnetic field; one is shunted by a simple resistance R_1. The unshunted coil has inductance l_0 and resistance r_0. Let L be the inductance of coil 4 and R its resistance, without the shunting resistance R_1. Then it can be shown that at frequency 10 s, and with coil 4 shunted by resistance R_1, the effective inductance L_{10s} and the effective resistance R_{10s} of the two coils connected in series will be

$$L_{10s} = \frac{L\,(1-a)^2}{1 + s^2\,a_0^2} + l_0; \quad R_{10s} = \frac{(a + s^2\,a_0^2)R_1}{1 + s^2\,a_0^2} + r_0 \tag{2}$$

Where $a = \dfrac{R}{R + R_1}$ and $a_0 = \dfrac{2\,\pi \times 10\,L}{R + R_1}$

At frequencies $10\,s = 20$ and $10\,s = 30$

$$L_{20} = \frac{L\,(1-a)^2}{1 + 4\,a_0^2} + l_0; \quad R_{20} = \frac{(a + 4\,a_0^2)\,R_1}{1 + 4\,a_0^2} + r_0$$

$$L_{30} = \frac{L\,(1-a)^2}{1 + 9\,a_0^2} + l_0; \quad R_{30} = \frac{(a + 9\,a_0^2)\,R_1}{1 + 9\,a_0^2} + r_0$$

Hence

$$\frac{L_{20} - L_{30}}{R_{30} - R_{20}} = \frac{L\,(1-a)}{R_1} = \frac{L}{R + R_1} = \frac{a_0}{2\,\pi \times 10} \tag{3}$$

As may be seen later eq. 3 has proved very useful in the theory of the design of inductive balancing networks.

If curves are plotted for L_{10s} and R_{10s}, the inductance and resistance curves given by eq. 3, then for the frequency interval from $10\,s = 5$ to $10\,s = 50$ the inductive network will balance the equivalent cable to the extent, only, that these curves coincide during that interval with curves A and B of Fig. 2. The problem of this study is, therefore, to adjust the physical constants of coils 3 and 4 (Fig. 3) so that within this frequency interval the curves for L_{10s} and R_{10s}, as given by eqs. 2 coincide as nearly as possible with curves A and B of Fig. 2. The frequency interval between 5 and 50 cycles per second is considered here because it is the important interval at the signaling speeds of the cable under consideration, that is, 600 letters per minute.

Assume that these curves coincide at frequencies 20 and 30, and that each section of the inductive network represents ten nautical miles of the equivalent cable; then

$$\left.\begin{aligned} &10\,L_{20}' = L_{20};\ 10\,L_{30}' = L_{30} \\ &\text{and} \\ &10\,R_{20}' = R_{20};\ 10\,R_{30}' = R_{30} \end{aligned}\right\} \tag{4}$$

Under what conditions will these coincidences occur? It will be shown presently that equation

$$\frac{L_{20} - L_{30}}{R_{30} - R_{20}} = \frac{L_{20}' - L_{30}'}{R_{30}' - R_{20}'} \tag{5}$$

determines these conditions completely, because (see eq. 3) it assigns definite values to all of the physical constants in eq. 2. These constants are: a_0, l_0, R_1, R, r_0, and $a = R/(R + R_1)$. The assumptions (eq. 4) leading to eq. 5 are, therefore, the foundation for the procedure of designing the inductive network considered here.

The right-hand member of eq. 5 has, according to Fig. 2, a definite numerical value equal to 1/109 approximately. The left-hand member of eq. 5 is equal to $a_0/(2\,\pi \times 10)$ according to eq. 3. Hence

$$a_0 = \frac{2\,\pi \times 10}{109} = 0.576$$

and

$a_0^2 = 0.332$

This constant a_0 in the equations of the inductance and resistance curves of the network is therefore fixed by experiment. The other constants in eqs. 2 also are definitely fixed by experiment as follows:

$$\frac{L_{20} - l_0}{L_{30} - l_0} = \frac{10\,L_{20}' - l_0}{10\,L_{30}' - l_0} = \frac{1 + 9\,a_0^2}{1 + 4\,a_0^2}$$

Whence $l_0 = 18.30$ mh.

Again from eq. 2

$$(1-a)^2\,L' = \frac{(10\,L_{20}' - l_0)\,(1 + 4\,a_0^2)}{L} = 56.57 \text{ mh.}$$

Having selected a convenient value for L, the inductance of the shunted coil without R_1, the constant $a = R/(R + R_1)$ also is fixed. It is 0.387 when $L = 0.15$ henrys. Since

$$1 - a = \frac{R_1}{R + R_1} = \frac{R_1\,a_0}{2\,\pi \times 10\,L} = 0.613$$

$$R_1 = \frac{2\,\pi \times 10\,L \times 0.613}{a_0} = 10.0 \text{ ohms}$$

$$R = \frac{a\,R_1}{1 - a} = 6.3 \text{ ohms}$$

$$r_0 = 10\,R_{20}' - \frac{(a + 4\,a_0^2)\,R_1}{1 + 4\,a_0^2} = 20.0 \text{ ohms}$$

If therefore the physical constants of the two inductance coils in the sections of the inductive network have the values which have been calculated by means of eq. 5, then the inductance and resistance values will

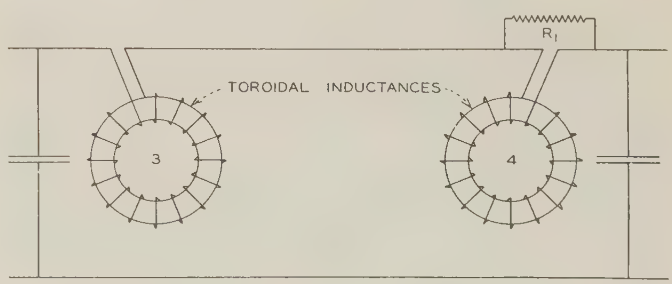

Fig. 3. Schematic diagram of a section of inductive balancing network with no external magnetic field

be as indicated in eqs. 4. The question now arises as to how the effective inductance and resistance curves of the two structures compare at other frequencies. This comparison is obtained easily by substituting successively different values of frequency from $10\,s = 5$ to $10\,s = 50$ in the following equations:

$$\left.\begin{aligned} L_{10s} &= \frac{56.57}{1 + 0.332\,s^2} + 18.3 \\ R_{10s} &= 20.0 + \frac{(0.386 + 0.332\,s^2)\,10}{1 + 0.332\,s^2} \end{aligned}\right\} \quad (6)$$

These equations are obtained by inserting in eqs. 2 the values of the constants just calculated.

The values of inductance and resistance thus calculated from eqs. 6 were plotted by dots in the curves of Fig. 2. The overlapping of the effective inductance and resistance curves of the equivalent cable with those of the inductive network certainly is remarkable. However, the overlapping of the terminal reactance and resistance curves is even closer as is indicated by curves A and B of Fig 1. In these curves the small circles denote values determined by wheatstone bridge measurements on the cable and referred to previously, while the dots denote values calculated by eqs. 1 from L_{10s} recorded on curves A and B of Fig. 2, and verified later experimentally by measurements on the inductive balancing network after this had been constructed.

Since the terminal impedance curves of the inductive network and of the equivalent cable coincide within the frequency interval between 5 and 50 cycles per second it follows that the network will balance the cable within that frequency interval. Practical operations are in complete agreement with this theoretical result. The same method of procedure was followed in the design and construction of inductive network balances of this type for other cable terminals, and in each case the result was just as satisfactory as in the case just described.

Irregularities in Speed-Torque Curves of Induction Motors

Recent investigations have thrown light on the hither to obscure causes of "cusps" in the speed-torque curves of polyphase induction motors, causing the motors to "crawl" at reduced speed or to be noisy and to vibrate under load. Results of some of these studies are described in the three articles following the introduction below.

SPEED-TORQUE curves of polyphase induction motors on test never have agreed with the smooth calculated characteristics. As a result of these unpredictable "hooks" or "cusps" in the speed-torque curve, some motors are found to crawl at unexpected speeds or are so noisy as to be u eless for all practical purposes. Various explanations have been advanced as to the cause of these irregularities, but no satisfactory method of definitely predetermining the speed-torque curve could be found.

Certain factors, such as the harmonics in the revolving field caused by the distributed winding, or the relative number and shape of the stator and rotor slots, are known to influence the shape of the curve. However, dependence upon empirical rules for the selection of rotor slots always has been necessary. Rules such as the use of twice a prime number for rotor slots, or the avoidance of less than 20 per cent difference in stator and rotor slots, have passed from one designing generation to the next. A German engineer, Dr. W. Stiel, published other empirical rules devised from an extensive investigation of a large variety of slot combinations. As is to be expected, all these empirical rules not based on a knowledge of the disturbing phenomena often result in unpleasant surprises. Hence today manufacturers are led to the wasteful method of building a series of rotors with different slots whenever a new line of induction motors is required, to find by actual test which of the rotors is most satisfactory.

In the first two of the following three articles, attempts are made to determine the cause of the irregularities in the speed-torque curves, and to formulate rules for the prediction of these characteristics. The first article, by Kron, gives consideration to the slot combinations in the stator and rotor and indicates that the most powerful disturbing effects are due not to the

distribution of windings in slots, but to the existence of the slot openings in the stator and rotor. As the result of a careful, mathematical analysis based on a new method of attack, involving the concept of "revolving permeances," definite rules are laid down by the author regarding the occurrence of vibration, noise, and crawling of induction motors. The second article, by Trickey, is concerned with the effect of harmonics in the rotating field, and the results, while not entirely in agreement with those in the first article, appear to be well substantiated by test. A possible explanation of the apparent discrepancy between these two investigations is that the first is concerned with rotors having a small number of slots so that the slots are relatively important, while the second deals more particularly with rotors having a large number of slots so that the slots become less important and the harmonics in the field have an increasing influence.

The third article of this group is a contribution from England, and gives the derivation of a formula for determining the short-circuit current obtained with skewed rotor slots in per cent of the short-circuit current obtained without skewed slots. By its use, the value of short-circuit current may be predicted for any angle of skew of the rotor slots. While this subject is somewhat controversial, it is of interest in connection with the other two articles, as skewing is resorted to in an effort to eliminate noise and crawling of induction motors at reduced speed.

Slot Combinations of Induction Motors

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AMONG the suggestions advanced as to the cause of irregularities in the shape of the speed-torque curves of polyphase induction motors which cause them to crawl at reduced speeds or to have excessive vibration and noise, is that the harmonic fluxes introduced by the distribution of the stator and rotor windings in slots may cause these irregularities. However, the conclusions of this analysis are not borne out by the facts, and the investigations on which this article is based show that the most powerful disturbing effects are due not to the distribution of the windings, but to the presence of the slot openings in the stator and rotor.

The existing methods of analyzing the influence of slot openings were found to be unsuitable for this particular problem, so another method of attack was devised, introducing the concept of "revolving permeances" to find what fluxes exist in an induction motor besides the fundamental flux when both stator and rotor are slotted, and what is the speed of these parasitic fluxes as the rotor rotates at any particular speed. With this conception and the general term of Fourier's series, the necessary rules and formulas may be expressed in simple forms.

Based upon "Induction Motor Slot Combinations" (**No. 31-46**) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 26-30, 1931.

Revolving Permeances

It will be assumed that the slots are replaced by *effective* slots having rectangular shapes, as in Fig. 1(a), and that the lines of flux are parallel in the gap. To avoid the disturbing use of subharmonics and fractional harmonics, a flux with one pair of poles (two poles) will be called the first harmonic and a flux with p pairs of poles will be called the pth harmonic.

Let first both stator and rotor teeth be removed. The resulting gap has a constant permeance $\mathcal{P}_c$ and is represented in Fig. 1(b) by unit height.

Next, let the stator teeth be introduced. At those points around the circumference where stator teeth exist, the permeance increases. This change of permeance can be considered as if an additional stationary permeance, $\mathcal{P}_s$ consisting of rectangles, has been introduced. If the number of stator teeth is G_1, this permeance $\mathcal{P}_s$ can be expressed as a constant term plus a series of harmonic permeances $\Sigma A_k \cos k\, G_1\, x$ where k is any integer. The largest of these is $A \cos G_1\, x$, the harmonic permeance having G_1 pairs of poles.

Let now the stator teeth be removed and the revolving rotor teeth, G_2 in number, be introduced. This is equivalent to introducing an additional revolving permeance $\mathcal{P}_r = \Sigma B_k \cos (k\, G_2\, x - v\, k\, G_2\, \omega\, t)$ where v is the ratio of the rotor speed to the two pole synchronous speed S. (S is 3,600 with 60 cycles.) The speed of each of these permeances is $v\, k\, G_2/k\, G_2 = v$. The largest permeance is $B \cos (G_2\, x - v\, G_2\, \omega\, t)$, the one with G_2 pairs of poles.

If the stator teeth are *not* removed when the rotor teeth are introduced, at those points along the circumference where no stator teeth exist, the additional permeance is $\mathcal{P}_r$, same as above, but at those points where stator teeth do exist, the additional permeance is larger than $\mathcal{P}_r$ by the amount of an oscillating permeance $\mathcal{P}_o$. This permeance $\mathcal{P}_o$, due to the coexistence of slots, is much larger than $\mathcal{P}_s$ or $\mathcal{P}_r$. In decreasing the air-gap, $\mathcal{P}_s$ or $\mathcal{P}_r$ change very slightly, but $\mathcal{P}_o$ increases very rapidly.

As the rotor revolves, each part of $\mathcal{P}_o$ describes a peculiar cycle. The width of each rectangle increases from zero to a definite value, then moves along the

periphery, soon decreases and finally disappears. In spite of its complicated behavior it can be expressed easily in a Fourier's series by noting that if two series representing $\mathcal{P}_s$ and $\mathcal{P}_r$ are multiplied together the product represents the oscillating permeance $\mathcal{P}_o$. Hence

$$\mathcal{P}_o = \Sigma\, C_k \cos\left[(k_1 G_2 \pm k_2 G_2)\, x \pm v\, k_2 G_2\, \omega\, t\right]$$

The largest among these revolving double-infinity harmonics is the one having $(G_1 - G_2)$ pairs of poles,

$$\mathcal{P}_o = C \cos\left[(G_1 - G_2)\, x + v\, G_2\, \omega\, t\right]$$

revolving with a speed $[G_2/(G_1 - G_2)]\, v$. If G_2 is larger than G_1 this permeance revolves forward; if smaller, it revolves backward. With decreasing air-gap $\mathcal{P}_o$ increases rapidly and may reach a value of the same order of magnitude as the constant gap. It is this very permeance which causes most of the trouble.

Now, if p equals the number of pairs of poles of the stator winding, and an m.m.f. wave $M = M_r \cos (p\,x - \omega\, t)$ exists in the stator, it produces with each of the permeances two fluxes since flux = m. m. f. $\times$ permeance. Based on this theory rules can be formulated as to the behavior of induction motors with regard to crawling, vibration, and excessive noise. These rules, summarized below, have been substantiated by many tests and indicate that the assumption of rectangular rotor slots is justified.

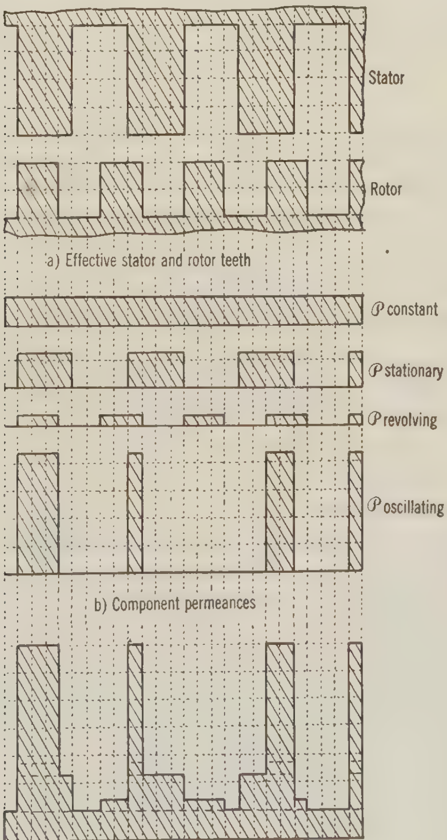

Fig. 1. Effective tooth shapes, and component and resultant permeances due to slot openings

Summary of Rules

A. Vibration and noise are liable to be present under the following conditions.

1. When the slots differ by one or by the number of poles plus or minus one, the fundamental m. m. f. and the oscillating permeance produce a flux differing by two poles from the fundamental flux. When the speed of the resulting unbalanced pull is the same as the critical speed of the rotor circular vibrations and noise occur.

2. When the slots differ by half the number of poles, the fundamental m. m. f. and the oscillating permeance produce a fundamental single-phase flux. When the frequency of torsional vibrations is the same as the critical frequency of the rotor, torsional vibrations and noise occur.

3. When the slots differ by the number of poles the fundamental m. m. f. and the oscillating permeance produce a parasitic fundamental flux revolving with a different speed than the fundamental flux. These two fluxes set up torsional vibrations and noise, and also rumbling noises unaccompanied by critical vibrations.

The chances that the noise occurs in the working range are greater with smaller number of poles, higher speed and with smaller critical speeds. When these noises do occur, the motor is practically useless.

B. Crawling may be present under the following conditions.

1. When the slots differ by the number of poles and the rotor has more slots than the stator, the fundamental m. m. f. and the oscillating permeance produce a parasitic fundamental flux. At a rotor speed $S\,(2/G_2)$ the speed of the parasitic flux is the same as the speed of the fundamental flux, the two fluxes lock and the motor crawls as if it were a synchronous motor (reaction machine effect). When the rotor has less slots, the synchronous crawling occurs at a negative speed.

2. When the rotor slots are greater than $(G_1 + p)$ by, say 80 per cent, the fundamental m. m. f. and the stator slot-opening produce a flux having less poles than the number of rotor bars. At a rotor speed $S/(G_1 + p)$ the motor crawls due to induction motor effect.

3. When the rotor slots are greater than $(G_1 - p)$ by, say 80 per cent crawling occurs at $S/(G_1 - p)$ if driven backward, due to the same reason as in 2.

4. When the rotor slots in a two-phase motor are divisible by the number of poles, the fifth harmonic flux due to the distribution of winding may cause crawling at one-fifth synchronous speed.

5. Any two-phase motor may crawl at one-third synchronous speed if driven backward, due to the backward revolving third harmonic flux caused by the distribution of windings.

6. When $G_2/2\,p$ is an integer equal to or close to unity, crawling may occur at S/G_2 due to the "Görges" effect.

7. When the vibrations under A occur at low speeds, the motor crawls.

8. When the harmonic flux, due to the distribution of winding, is large, say larger than 10 per cent of the fundamental, the motor may crawl.

C. Smaller irregularities and hooks in the speed-torque curve may appear under the following conditions.

1. When the rotor slots are greater than $(G_1 + p)$ a hook occurs at $S\,(G_1 + p)$ r. p. m.

2. When the rotor slots are greater than $(G_1 - p)$ a hook occurs at $S/(G_1 - p)$ r. p. m. if the motor is driven backward.

3. When the rotor slots are divisible by the number of poles, a hook occurs at S/G_2 r. p. m.

4. When the rotor slots are divisible by the number of poles, a hook occurs at one-seventh synchronous speed in a three-phase motor and at one-fifth synchronous speed in a two-phase motor. In both cases, the hook is accompanied by another hook at S/G_2 r. p. m.

5. When $G_2 = 2\,p\,(1 + k\,\psi)\,2\,p$, where ψ = number of phases, a small synchronous locking (synchronous motor) effect occurs at $S\,(2/k_2 G_2)$ r. p. m.

6. Any two-phase motor has a hook at one-third synchronous speed if it is driven backward.

7. When a winding introduces a harmonic flux larger than, say 8 per cent of the fundamental, it always produces a hook.

8. When the vibrations under A occur at higher speeds, proportionally smaller hooks occur at those speeds.

It should be emphasized that these rules are not necessarily complete. Those for smaller noises, which make the motor useless only for certain applications, are not considered at all in this article, neither are the variations of torque during starting and at very low speeds.

Field Harmonics in Induction Motors

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CUSPS in the speed-torque curves of induction motors have been attributed to several causes; first, to harmonics in the rotating field; second, to the synchronous locking-in of stator and rotor harmonics as shown by Dreese; and third, to the effect of the slot openings as shown by Kron. The present article is devoted exclusively to the study of the first cause, and indicates that harmonics in the field form do have a very definite effect on the speed-torque curve.

It may be assumed that each harmonic of the rotating m.m.f. causes a proportional rotating flux, and that each of these flux harmonics acts in the motor as if it were present alone. It then produces a small speed-torque curve whose torque is proportional to the fundamental torque, and whose speed is l/h times the speed of the fundamental for the same slip, where h is the order of the harmonic. On this basis,

$$T_h = h\, K_h^2\, C^2\, K^2\, T_1$$

where

T_h = harmonic torque

K_h = magnitude of harmonic m.m.f. as a fraction of the fundamental

C = skew factor

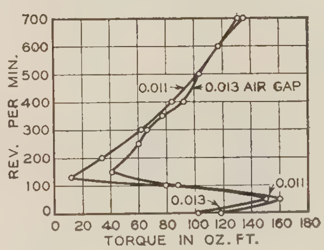
K = distribution factor, dependent on the number of rotor bars

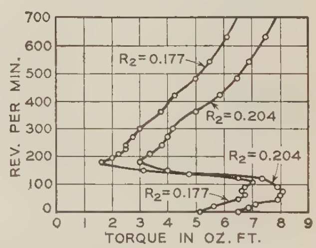
T_1 = fundamental torque at the same slip

As the harmonic torques do nothing but harm, they are eliminated or made as small as possible in normal design. K_h the magnitude of the harmonic m.m.f. is reduced by making the revolving field as nearly sinusoidal as possible. C may be reduced to zero for any one harmonic by skewing through twice the harmonic pole pitch. K is a function of the number of rotor bars, and is based on the fact that most induction motor theory is developed assuming an infinite number of bars. This brings a distribution factor of 0.637 into the formulas. With even as few as four bars per pole this factor changes little, but for the harmonic fields, the number of rotor bars per pole may be one or less. With one bar per pole K equals 2.46 and with one bar for two poles it becomes zero. However, since small numbers of rotor bars may bring in dangerous synchronous cusps, it is safer to use a large number of rotor bars, and when K begins to approach its maximum value, control by the skew factor.

There are three other means of reducing the cusps that are not apparent from the equation. First, the equation assumes that the flux wave is exactly the same as the m.m.f. wave. However, increasing the air gap will smooth out the harmonics, as indicated by Fig. 2. Second, the slot openings tend to increase certain of the harmonics, and therefore the openings should be made as small as possible. Third, while the magnitude of the harmonic torque is not reduced by increasing the rotor resistance, the fundamental torque is increased, and the resultant minimum torque is much greater. A typical case is shown in Fig. 3.

In order to study the effect of field harmonics, a special motor was built. A 48-slot primary was used





Figs. 2 and 3. Test curves of effect of increasing air gap (left) and secondary resistance (right)

to give sufficient slots per pole for the special windings, and to reduce the effect of slot openings, as the coil angle covered two or more slots. The rotor was chosen with 60 slots, a multiple of three to eliminate any possibility of the synchronous effect noted by Dreese, and of a greater number of slots than the stator to reduce "cogging" and to avoid possibility of the unlucky combinations that have occurred so many times with small numbers of rotor slots.

Four separate windings were placed in the stator, all of different wave forms, and so located that their fundamental fluxes coincided exactly. The windings were all three-phase, four pole, 60 cycles, and designed for the same fundamental flux. The wave analysis of each winding is given in Table I, the meaning of the

Based upon "Cusps in the Speed-Torque Curves of Induction Motors" (No. 31-71) presented at the A.I.E.E. North Eastern District meeting, Rochester, N. Y., April 29-May 2, 1931.

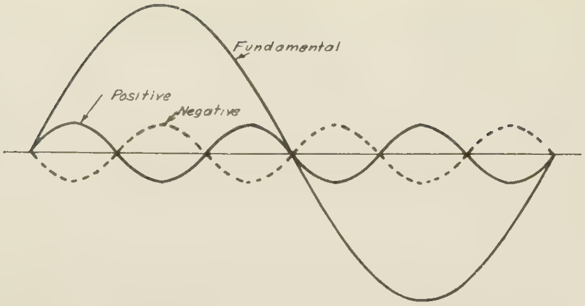
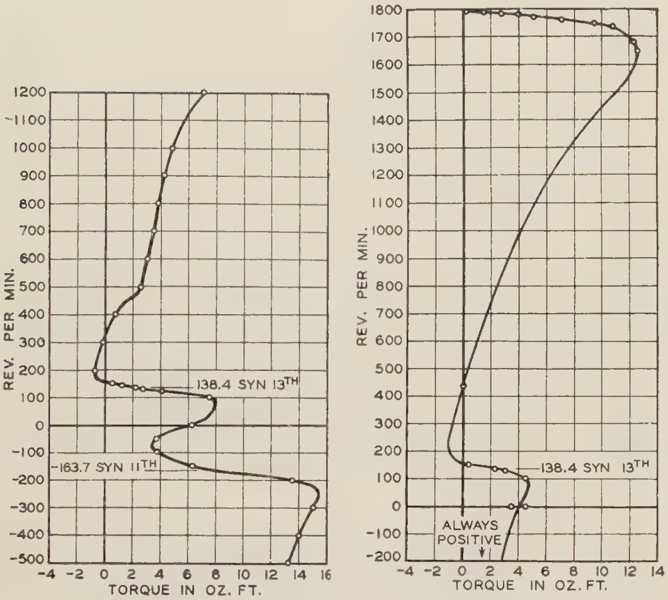
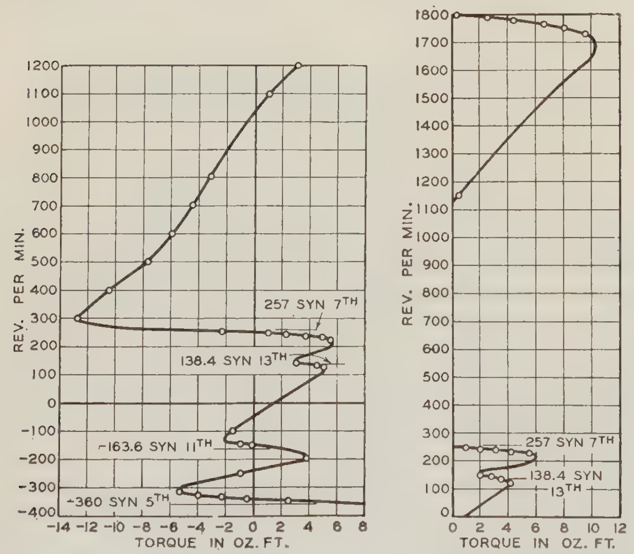


Fig. 4. Meaning of positive and negative signs of m.m.f. analysis presented in Table I



Figs. 5 and 6. Lower part of speed-torque curve of winding A at 100 volts (left); and speed-torque curve of winding B at 110 volts (right)



Figs. 7 and 8. Lower part of speed-torque curve of winding C at 110 volts (left); and speed-torque curve of winding D at 110 volts (right)

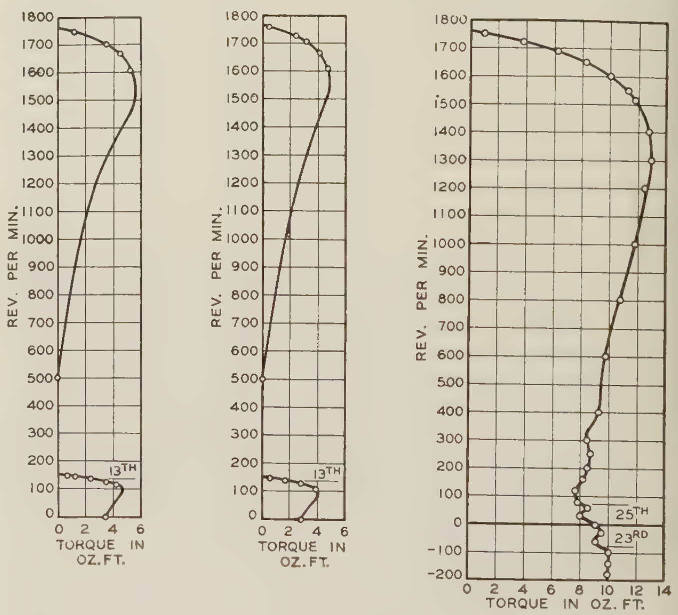
positive and negative signs being indicated in Fig. 4. The four separate windings were arranged as follows:

Winding *A* Two slots per phase per pole, full pitch
Winding *B* Two slots per phase per pole, two-thirds pitch
Winding *C* One slot per phase per pole, full pitch
Winding *D* One slot per phase per pole, two-thirds pitch

This motor very clearly illustrates the effect of changing the wave form. Figs. 5, 6, 7 and 8 are the test curves of windings *A*, *B*, *C*, and *D* respectively. The speed-torque curves for windings *A* and *B* shown in Figs. 5 and 6 are nearly alike except for a difference

Table I—Magnitude of M.M.F. Wave—Per Cent

h Rot.	1 For.	5 Back.	7 For.	11 Back.	13 For.	17 Back.	19 For.	23 Back.	25 For.
Wdg.									
A	+100	+ 5.37	− 3.84	−9.1	−7.7	−1.58	+1.41	+4.35	+4.00
B	+100	− 5.37	+ 3.84	−9.1	−7.7	+1.58	−1.41	+4.35	+4.00
C	+100	+20.	+14.3	+9.1	+7.7	+5.88	+5.26	+4.35	+4.00
D	+100	−20.	−14.3	+9.1	+7.7	−5.88	−5.26	+4.35	+4.00
A + *B*	+100	0	0	−9.1	−7.7	0	0	+4.35	+4.00
C + *D*	+100	0	0	+9.1	+7.7	0	0	+4.35	+4.00
A + *B* + *C* + *D*	+100	0	0	0	0	0	0	+4.35	+4.00
C − *D*	0	+20.0	+14.3	0	0	+5.88	+5.26	0	0



Figs. 9, 10 and 11. Speed-torque curves of windings A + B at 110 volts (left), windings C + D at 110 volts (middle), and windings A+B+C+D at 230 volts (right)

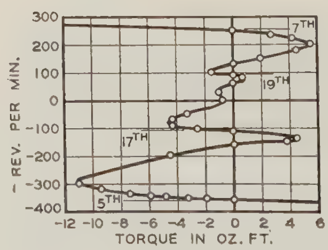


Fig. 12. Section of speed-torque curve of windings C—D at 115 volts

in reactance due to one winding being deeper in the slots. As may be noted, the generator torque of the 13th harmonic is great enough to cause the resultant torque to become negative and the motor operates at the low speed of the 13th harmonic and will not rise to full speed by itself. It will be noted in Fig. 7 for winding C that the 5th and 11th harmonics cause stable operation in opposite direction to the fundamental field.

It was also possible to secure other wave shapes by connecting the windings in different series combinations. Figs. 9, 10, and 11 further illustrate the effect of such recombination on the wave form. In these cases, certain of the harmonics cancel each other. Another method of illustrating the fact that the harmonic torques are present and are of considerable magnitude, is to place two windings in series with fundamental waves opposing and harmonic waves assisting. Fig. 12 shows the case of opposing windings C and D.

An attempt has been made in this article to bring out first, that the harmonics in the field form have a very definite effect on the speed-torque curves, and second, that the assumption of each harmonic acting separately, while not rigorously correct, is useful in determining the speed at which cusps are likely to occur.

Skewed Slots in Induction Motors

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INDUCTION MOTOR slots are usually skewed to prevent "cogging" and noise on load, but indiscriminate skew irrespective of number of poles, especially when this number is large, leads to very large reduction of short circuit current and motor performance. The reduction of short circuit current is due not so much to increase of leakage reactance as to an unbalanced component of mutual flux.

In the following theory expressions are given for the ratio of short circuit current with skewed slots to short circuit current without skew, as a function of "dispersion coefficient" τ and skew angle.

For the sake of simplicity, the motor is assumed to

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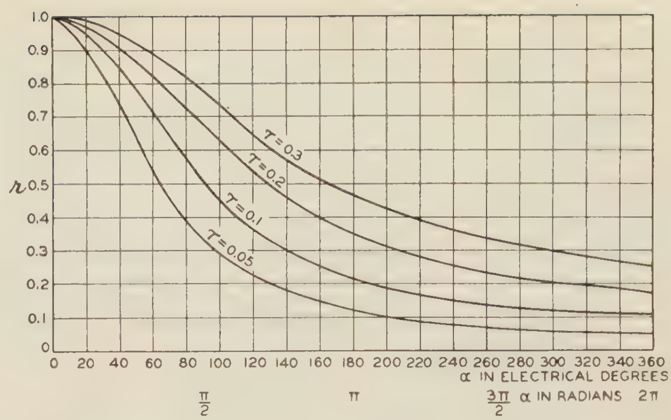

Fig. 13. Relation between short circuit currents, "dispersion coefficient" and skew angle

possess negligible primary and secondary resistance. The symbols used are as follows:

$$\tau = \frac{X}{M} = \frac{\text{magnetizing current}}{\text{short circuit current without skew}} \text{ (approximately)}$$

X = total leakage reactance

M = mutual reactance

$$f = \text{skew factor} = \frac{2 \sin \frac{\alpha}{2}}{\alpha}$$

$$\alpha = \text{skew angle} = \frac{\text{slot pitch skew}}{\text{total slots}} \times \text{pole pairs} \times 2\pi \text{ radians}$$

V = applied voltage

I_1 = primary current

I_2 = secondary current referred to primary

$$r = \frac{\text{short circuit current with skewed slots}}{\text{short circuit current without skewed slots}}$$

If equal primary and secondary leakage reactance is assumed, we get the usual transformer equations

$$j I_1 \left(1 + \frac{\tau}{2}\right) M + j I_2 M f = V \quad (1)$$

$$j I_2 \left(1 + \frac{\tau}{2}\right) M + j I_1 M f = 0 \quad (2)$$

From eq. 2

$$I_2 = -\frac{I_1 M}{M\left(1 + \frac{\tau}{2}\right)} f = -\frac{I_1 f}{\left(1 + \frac{\tau}{2}\right)} \quad (3)$$

Substituting eq. 3 in eq. 1 we obtain

$$j I_1 \left(1 + \frac{\tau}{2}\right) M - j I_1 \frac{M}{1 + \frac{\tau}{2}} f^2 = V$$

$$I_1 = \frac{V}{jM\left[\left(1+\frac{\tau}{2}\right) - \frac{f^2}{1+\frac{\tau}{2}}\right]} \tag{4}$$

Without skew, $\alpha = 0$, hence $f = 1$

Therefore

$$r = \frac{\dfrac{V}{jM\left[\left(1+\frac{\tau}{2}\right) - \frac{f^2}{1+\frac{\tau}{2}}\right]}}{\dfrac{V}{jM\left[\left(1+\frac{\tau}{2}\right) - \frac{1}{1+\frac{\tau}{2}}\right]}}$$

$$= \frac{\left(1+\frac{\tau}{2}\right)^2 - 1}{\left(1+\frac{\tau}{2}\right)^2 - f^2} \tag{5}$$

From eq. 5 we can plot the ratio r as a function of τ and f. Curves are given in Fig. 13, which can be used as a guide when choosing the skew angle. It will be noticed that a small error, due to the various assumptions made for the sake of mathematical simplicity, is introduced for large values of τ at $\alpha = 360$ degrees, but skew of this order naturally is never met with in practise.

A Study of the Three-Circuit Transformer

THREE independent electrical circuits which are coupled together magnetically may be represented by an equivalent circuit developed from fundamental equations. In general, these transformers may be divided into two distinct types depending upon the relative directions of the mutual fluxes between the three windings. According to C. F. Estwick, (M'25) of the General Railway Signal Company, Rochester, N. Y., who discusses this type of transformer in a current A.I.E.E. paper, any arrangement of three coupled circuits will have the characteristics of either one or the other of the two types mentioned.

In the first type of transformer discussed by the author the coils in each circuit, or the cores on which they are mounted, are parallel to each other or arranged in the form of a Y. Under such conditions it is practically impossible to have a mutual flux threading through all three coils. In the second type the three coils are wound on one core or otherwise arranged on separate cores placed so that a path is provided for magnetic flux to interlink with the conductors in all three circuits. The author sets up equivalent circuits for both types of transformers, and for these derives equations which take into consideration the various mutual fluxes. To demonstrate the applicability of the formulas derived one simple typical problem is presented for each type of transformer.

Abstracted from "The Three-Circuit Transformer" by C. F. Estwick, (No. 31-69) presented at the A.I.E.E. North Eastern District meeting, Rochester, N. Y., April 29-May 2, 1931.

Remote Reading of Watthour Meters

A scheme is described whereby watthour meter readings may be "observed" over regular subscribers' telephone circuits.

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REMOTE READING of electric meters in residences is not feasible by any of the several telemetering schemes so far developed on account of the amount and nature of special apparatus required at the meters being read. A scheme worked out in the General Electric Laboratory is described here in which the bulk of the apparatus is concentrated at the power company's premises, a simple electromechanical device being the only apparatus installed at the meter itself.

In this proposal, connection between the power company's "observing" apparatus and the consumer's meter is made by means of telephone lines, the connection being made through the power company's connection with the telephone central exchange, thence to the consumer's residence over the telephone company's regular subscriber's circuit. A special mutual agreement would have to be reached, of course, to permit the necessary interconnection of power and communication equipment. Any system of remote

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A beat-frequency audio generator with four tuning dials corresponding to the four dials of the watthour meter is installed at the power company's office (left). Attached to the meter (right) is a simple electromechanical vibrating device fitted with four rows of ten reeds each, one for each digit. This unit is actuated by an electromagnet which in turn is energized by the audio generator via the telephone line. Each reed resonates at a different frequency but all within the frequency range of the generator. To obtain a reading the observer signals the telephone central-office operator and gives her the number of the party whose meter is to be read. After the connection has been established (without ringing or otherwise disturbing the consumer) the observer switches on the audio generator to read the "thousands" dial. As the generator frequency is varied, the reeds of the "thousands" row vibrate into contact with the spindle separately and successively until one is found which makes contact with one of the ten segments mounted spirally on the spindle surface. This short circuits the electromagnet coil and causes a change in the signal to which the observer is listening. The position of the tuning dial then indicates directly the position of the "thousands" pointer. In like manner the readings of the other pointers are ascertained.

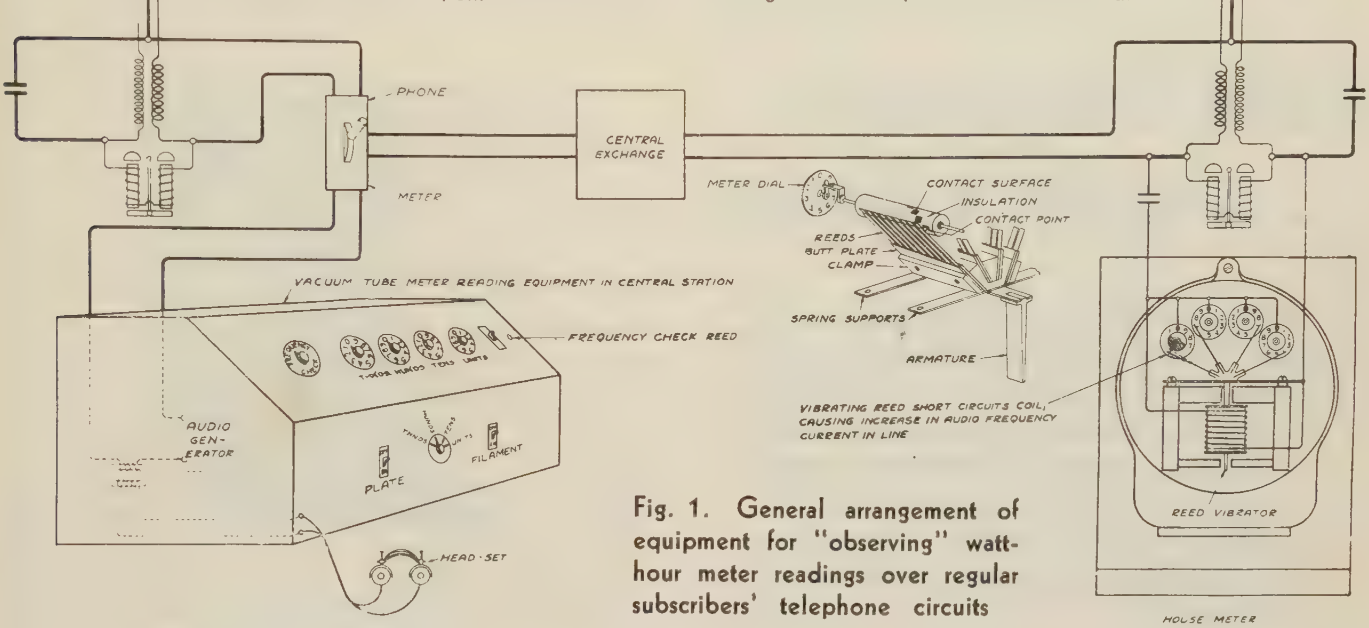

Fig. 1. General arrangement of equipment for "observing" watthour meter readings over regular subscribers' telephone circuits

reading quite obviously must justify itself from a cost standpoint. Average cost for reading a meter in a city district has been estimated at from 1.5 to 2.0 cents, and from 10 to 15 cents in a rural district. On the basis of these estimates the maximum justifiable investment for remote reading equipment is \$4 for city and \$30 for rural districts. An additional expense item would be involved in the use of the telephone company's lines. Also the fact that the plan postulates that each consumer is a telephone subscriber must be taken into consideration.

The general arrangement of equipment, together with the scheme of operation are indicated in Fig. 1, while in Fig. 2 may be seen a standard watthour meter rigged up for experimental purposes. The four tuning dials of the audio generator in the power company's office are arranged so as to indicate directly the positions of the four meter hands. Thus, after all four dials of the generator have been adjusted to "find" the positions of their respective meter hands, these tuning dials directly represent the watthour meter reading.

Several difficulties were experienced during the course of the experiments. One of the chief of these concerned the vacuum tube audio generator. Most of these difficulties were overcome, however, with the installation of a more stable and precise unit, and the provision of means for checking its accuracy. Variation in the frequency of response of the reeds due to wearing of the contact tips or temperature differences was found to be negligible. However, serious difficulties would be

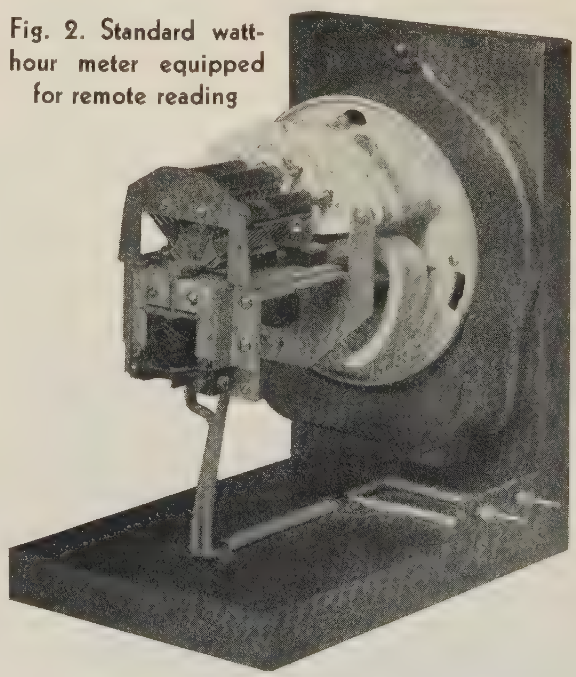

Fig. 2. Standard watthour meter equipped for remote reading

experienced in carrying out the scheme where party telephone lines are in use, or where machine switching exchanges are employed. Additional equipment no doubt would be required under these conditions.

Equipment and circuit arrangements described in the foregoing are mentioned merely as a suggestion of a future possibility. Engineering phases of the problem have been proved by extensive laboratory experiments to be capable of relatively simple solution, but of course the commercial application is quite another question and naturally would hinge principally upon the intercompany agreements that would be necessary before established communication channels could be put to such use.

Cable Temperatures at Variable Loading

Accurate methods, long available for calculating the temperatures in power cables during steady loads now can be supplemented by methods of calculating cable temperatures during fluctuating loads. Under favorable circumstances these give accuracies within 5 per cent. Further, the method is simple, and calculations can be made readily.

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MAXIMUM USE of the large investment in power cables can be made only if accurate information on the temperatures and loading limits of cables during variable loads is available. Although there are now fairly accurate methods for calculating the temperature rise when the load is steady, until recently no attempt was made to obtain even a moderately rigorous solution for the case of variable loading.

A point-by-point method of solution for variable loading based on the assumption that the temperature of the conductor rises exponentially with time was given in the JOURNAL of the A.I.E.E., October 1930, p. 855. This, however, is only approximately true and the theory presented below tends to show that the temperature curve rises faster at first, and then slower than the exponential law would allow, for example at 1 hr. after the load is applied.

By the use of Bessel functions, a rigorous solution of the problem of temperature rise from sheath surface to conductor is presented for single-conductor cables and three-conductor cables of shielded type H construction. Modifications of the cable constants allow the theory to be applied with reasonable accuracy to cables of standard belted construction. The heat flow cycle is resolved into harmonics and each harmonic solved separately for temperature at the conductor. Then the various harmonics of temperature are combined in their proper phase relation to obtain the temperature cycle. For purposes of assigning emergency ratings, a solution making use of the Fourier integral is derived for suddenly applied steady load.

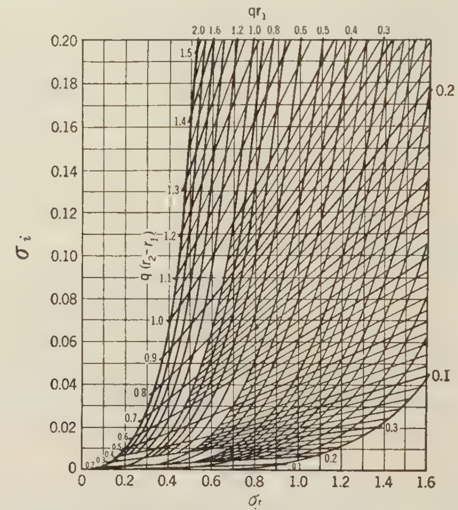

Fig. 1. Heat flow constant: $\sigma = i_2 k_1 - i_1 k_2$

$i_1 = I_0 \sqrt{j}\, q\, r_1 \qquad i_2 = I_0 \sqrt{j}\, q\, r_2$

$k_1 = K_0 \sqrt{j}\, q\, r_1 \qquad k_2 = K_0 \sqrt{j}\, q\, r_2$

Solution for Daily Load Cycle

Derivation of the general equations for temperature in a single-conductor cable leads to the following simultaneous equations:

$$\frac{Q_0}{\pi} - j\,\frac{q_c^2\, r_1^2\, T_1}{S_c} = \frac{2}{S_i\,\sigma}\,(q_i\, r_1\, \tau\, T_1 - T_2) \qquad (1)$$

$$\frac{D}{K}\,(T_2 - T_3) = \frac{2}{S_i\,\sigma}\,(T_1 - q_i\, r_2\, \psi\, T_2) \qquad (2)$$

In the solution for three-conductor cable, eq. 1 remains the same, and eq. 2 is written as follows:

Based upon "Temperatures in Electric Power Cables Under Variable Loading" (No. 31-75) presented at the A.I.E.E. North Eastern District meeting, Rochester, N. Y., April 29-May 2, 1931.

$$\frac{D}{3K}(T_2 - T_3) = \frac{2}{S_i\,\sigma}(T_1 - q_i\,r_2\,\psi\,T_2) \qquad (3)$$

where

T_1 = vector temperature at surface of conductor
T_2 = vector temperature at surface of insulation
T_3 = vector temperature of the air at the surface of the sheath
Q_0 = vector heat flow per conductor, equal to the $I^2\,R$ loss
Q_1 = vector heat flow per conductor at inside surface of the insulation
Q_2 = vector heat flow per conductor at outside surface of the insulation, or at outside surface of the sheath if sheath losses can be neglected as they are assumed to be in eqs. 2 and 3
r_1 = inside radius of the insulation
r_2 = outside radius of the insulation
D = diameter of the sheath
q_c = $\sqrt{\omega\,C_c\,\rho_c\,S_c}$
q_i = $\sqrt{\omega\,C_i\,\rho_i\,S_i}$
ω = $2\,\pi\,\times$ frequency of vector heat flow
C_c = specific heat of the conductor material
C_i = specific heat of the insulation material
ρ_c = specific gravity of the conductor material
ρ_i = specific gravity of the insulation material

The symbols σ, τ, and ψ represent complex constants, analogous to the general circuit constants of a transmission line, which depend on the constants and configuration of the cable. For ease in computation, charts of σ, τ and ψ based on Bessel functions have been prepared and are illustrated in Figs. 1, 2, and 3.

In carrying out any particular calculation, the watt loss in the cable is plotted for the load cycle assumed. This curve then is analyzed by well-known methods for its principal harmonics. The solution for temperature is obtained for each harmonic of heat flow and the results combined in their proper phase relation to give the resultant temperature cycle.

If the cable is installed in a duct and only approximate solutions are required, the value of T_3, the temperature of the air at the surface of the sheath can be assumed constant at the maximum value obtained over a 24-hour load cycle. Usually when the cable is installed in an ordinary duct bank T_3 will vary from 20 to 30 per cent of the total variation in temperature at the conductor. If T_3 is considered constant, its value becomes zero in eqs. 2 and 3, merely adding to the steady state component of the total temperature at the conductor, which is computed by well-known methods. Then the value of T_1/Q_0 will be constant in both phase and magnitude for any given cable. Hence, tables of T_1/Q_0 for any given cable may be compiled for the principal harmonics. These may be combined in their proper phase relation to obtain a solution for any load cycle.

On account of the effect of adjacent cables and the uncertainty of the constants of the duct bank, the best method of obtaining the air temperature at the sheath surface is by means of a maximum-reading thermometer surrounded by a thin shield of heat insulating material. It is generally conceded that the temperature in the duct outside the lead sheath is nearly the same throughout the space between the sheath and the duct and can be considered so in the solution for steady heat flow. Since the air has a very low thermal capacity, its temperature will follow the variations in the lead sheath very closely in phase. Hence, if the maximum value of this air temperature throughout the load cycle considered can be obtained, it may be added directly to the maximum temperature rise between this air and the conductor to obtain the total rise. The error caused by these temperature components being out of phase will be small, since the total variation in the air temperature is only about one-quarter of the total.

Solution for a Steady Load Suddenly Applied

The solution for a steady load suddenly applied is as follows:

$$T_0 = \frac{2\,Q_0}{\pi}\int_0^\infty \delta_r\,\frac{1}{\omega}\sin\omega\,t\,d\,\omega\,. \qquad (4)$$

where

T_0 = the temperature of the conductor at any time t after the steady load is applied
δ_r = the real part of the expression

$$\delta = -j\left\{\frac{\gamma}{\pi\,q_c\,r_1}\right\} \times \left\{\frac{1}{\dfrac{q_i\,r_1\,\tau}{S_i\,\sigma} - \dfrac{\eta}{S_i\,\sigma\,(S_i\,\sigma\,D + \eta\,q_i\,r_2\,\psi)} - \dfrac{q_c\,r_1\,\gamma}{S_c}}\right\}$$

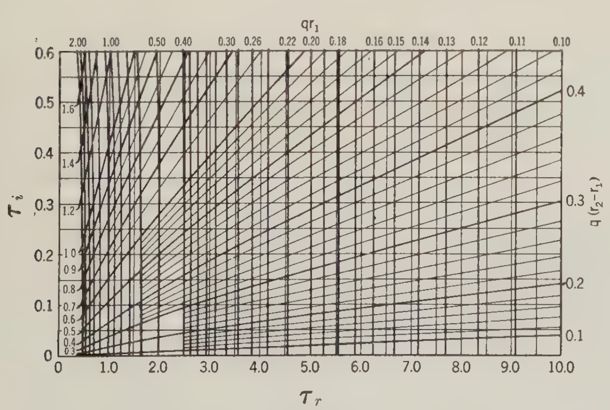

Fig. 2. Heat flow constant: $\tau = i_1'\,k_2 - i_2\,k_1'$

$i_1' = \sqrt{j}\,I_0'\,\sqrt{j}\,q\,r_1 \qquad k_2 = K_0\,\sqrt{j}\,q\,r_2$
$k_1' = \sqrt{j}\,K_0'\,\sqrt{j}\,q\,r_1 \qquad i_2 = I_0\,\sqrt{j}\,q\,r_2$

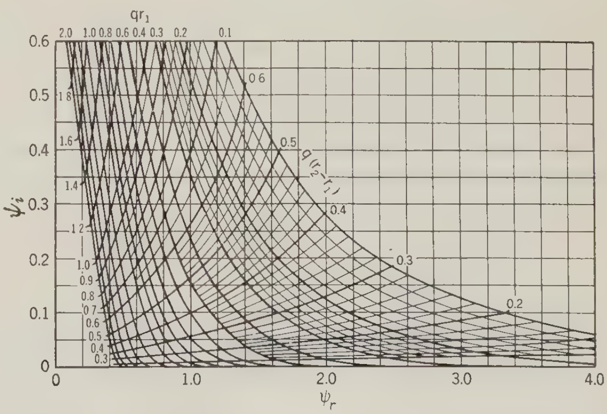

Fig. 3. Heat flow constant: $\psi = i_2'\,k_1 - i_1\,k_2'$

$i_2' = \sqrt{j}\,I_0'\,\sqrt{j}\,q\,r_2 \qquad k_1 = K_0\,\sqrt{j}\,q\,r_1$
$k_2' = \sqrt{j}\,K_0'\,\sqrt{j}\,q\,r_2 \qquad i_1 = I_0\,\sqrt{j}\,q\,r_1$

where

$\gamma = j q_c \; r_i/2$ (approximately)

$\eta = 2\,K$ for a single-conductor cable in still air

$\eta = 6\,K$ for a three-conductor cable in still air

The expression

$$\frac{1}{\omega}\,\delta_r \sin \omega t\, d\, \omega$$

is much too complicated to integrate by formal means, but it may be integrated readily by graphical methods, as with a planimeter. The value of the function is plotted for different values of t and integrated with respect to ω. Integrating from 0 to ∞ offers no difficulty here since the function converges rapidly as the value of ω is increased.

Standard Belted Cable

The equation for obtaining the steady state temperature rise of the conductor above the outside surface of the insulation has been given by R. W. Atkinson (Cable Geometry and Calculation of Current Carrying Capacity, A.I.E.E. Trans., Vol. XLII, 1923, p. 600) and by D. M. Simmons (Calculation of Electrical Problems of Transmission by Underground Cables, *Electric Journal*, August 1925, p. 366). This equation is as follows:

$$(T_1 - T_2) = \frac{Q_0\, S_i\, G}{2\,\pi} \qquad (5)$$

where G is the geometric factor.

For the shielded cable, the geometric factor is given by D. M. Simmons (Calculation of Current Capacity of Type H Cable, *Electric Journal*, Feb. 1926, p. 59) as follows:

$$G = l\,n \frac{r_2}{r_1}\,.$$

For the cable under consideration, obtain values of G from the curves given in the first of the two articles by Simmons just referred to, and solve for an equivalent S_i. In average cables this equivalent S_i is about double the true value for the insulation under consideration. This value of S_i may be used in eqs. 1 and 3, to obtain an approximate solution which it has been found gives the result within 5 or 10 per cent of the true values as far as the variable component of temperature is concerned. The rigorous solution for standard cable which would involve much more labor would have no value as long as the cable constants cannot be obtained with any greater accuracy.

Probable Magnitude of Errors

The change in resistance and dielectric loss with change of temperature for ordinary load cycles will not be over 5 or 6 per cent. If it is desired to take this into account a correction may be applied to the watt loss curve corresponding to the estimated temperature at that time. The value of temperature rise to be assumed in making this correction can be taken as half the ultimate temperature rise produced by the average watt loss over an hourly period. This is based on the fact that in average cables the temperature at the conductor reaches about half its ultimate temperature within an hour after a steady load is applied. The error introduced by change in resistance will be less than 0.5 per cent if this correction is made.

For sector conductors, the heat flow will be more concentrated around the regions of smaller radius but the error in neglecting the effect of sector shape will not be over 1 or 2 per cent.

Large conductors show considerable proximity effect when three conductors are concentrated in the small area inside the cable sheath. When three-phase current is flowing the current tends to crowd to the inside of the cable sheath. However, under the assumed condition of uniform current distribution the total variation in temperature through the conductor is only 1 deg. for ordinary load cycles. The smallness of this variation is due to the high heat conductivity of the copper. Hence, if the proper equivalent a-c. resistance is used for the cable in question, the error in temperature due to unsymmetrical current distribution will not be over 1 per cent. Of course this assumes that all the losses, excluding dielectric losses, are in the conductor. There are undoubtedly some losses in the sheath even in three-conductor cables, especially where large conductors are close to the sheath as they are in shielded cables. Not knowing definitely where all these losses are located, the conservative method would be to assume them all in the conductor.

Neglecting the temperature drop in the copper foil around the conductors in shielded cables introduces about 8 to 9 per cent error in the steady state solution. A similar error will be introduced in the solution for variable load. This error will be minimized in the total temperature rise if the steady state component of the temperature cycle is computed taking this drop in the foil into account as indicated in the second article by Simmons, previously referred to. Neglecting the heat storage in the lead sheath partially compensates for this error.

The over-all error in the method is thus not over 5 per cent and is probably much less if the watt loss curve is corrected for temperature. It is doubtful if the value of the insulation heat conductivity is known within 5 per cent plus or minus, so that it is useless to expend the labor necessary in obtaining greater refinement.

By means of computations based on this theory the temperature curve for any cable and load cycle may be calculated readily without excessive labor and with accuracies well within the accuracy of the cable constants. The effects of day-to-day changes in load cycle die out in a few hours so the theory can be applied to any day of the week with little effect from the previous day's cycle. Short-time overload ratings of any duration may be added to any initial loading with confidence that the calculated temperature rise will not be exceeded.

Progress is the Way Out of Depression

Intelligent self-interest, individually applied with sincerity of purpose toward the solution of every-day problems, is recommended as the most efficacious way out of present economic troubles. This is the fifth article of The Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?"

By
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Secy., Natl. Elec. Mfrs. Association

THE CURRENT economic depression cannot be ascribed to any single cause, nor will a panacea be found in righting any single wrong. Moreover, there is little of value at the moment in attempting to isolate and correct the major causes. They will emerge gradually from the present chaos as time provides a perspective; their evaluation will furnish the basis for long-time planning which should operate against recurrence. But this long-time planning, valuable as it would be, cannot be done now. The problem is too vast, the factors too many, and their inter-relations too complicated to be grasped and ordered by the human mind. So, in place of the coordinated effort which would be the outcome of a master plan, we must use what we have.

What have we? We have millions of men and women, each one of whom comprehends clearly some small part of the whole. If each of them spends each day in doing his individual best toward moving in the direction each knows to be right those things that each one understands, there is no fear of the outcome. There may be a wastage which would be absent in a master plan, but the whole will move forward surely and before a master plan, however imperfect, could be evolved.

This is an old and simple doctrine. Anyone can think it, and unfortunately it carries none of the exaltation that comes from the spectacular. But it is sound doctrine, and in the measure in which it is practised will be found the rate at which we will progress.

Human progress is not the result of the effort of the outstanding few, be they statesmen, industrialists, scientists, engineers, or inventors. It is the cumulative effect of the daily effort of the millions. The leaders but guide or accelerate it. The summation of the thousands of millions of small things is greater than the greatest large thing that the human mind can grasp. The combined effort of millions of average human beings will outweigh the most daring conception of the greatest vision the world ever has known. And these millions will put forth that effort, not as a result of ordered consideration, nor even by reason of instinctive realization, and least of all from any altruistic motive, but purely and wholly from self-interest. The efficiency of the process will lie in the degree in which that self-interest is intelligent; the hope of efficiency rises from the fact that there is growing comprehension that self-interest must be intelligent.

The average manufacturer perceives today that his interest and that of his workmen is a common one. He does not prosper if they do not. This long has been the conviction of the few, but it required the current condition to bring this realization home to the many. And again will be demonstrated the workings of this simple doctrine of mass effect. Eighteen months have increased the *quantity* of understanding more than the preceding eighteen years. Further, there has been made manifest the need for balance in the economic forces which make up our involved civilization. A force is constructive or destructive in the degree that it is or is not controlled. Production, whether of foodstuffs, of raw materials, or of finished goods, is constructive if balanced against consumption. It is destructive if unbalanced and guided only by unintelligent and immediate self-interest. Surely the past months have brought to the many a realization of this simple fact. From this realization there will as surely follow provision for assuring that balance.

The means are not yet clear, and a period of trial and error is to be expected before an approximate solution is found. However, the mere fact that stabilization of employment is economically dependent on controlled production, and consumption dependent on stabilized employment, will unite all elements in a common demand for that solution. This would not have been possible five years ago; but the thinking forced on the many in the past two years has brought an understanding of fundamentals which makes it not merely possible, but certain, and for the near future.

The present conditions are difficult to contemplate with mental serenity and undisturbed confidence, but they carry more of ultimate value than the prosperous years that preceded them. The growth of understanding by the many will form the foundation for a new and greater progress, for a civilization such as the world has not yet known. In this progress the engineer and the engineering method of basing procedure on determined fact will have a major part. The saying that "through adversity we progress" again will demonstrate its truth.

Editor's Note: Pursuant to the invitation of The Engineering Foundation, the editors will be happy to receive comments, suggestions, criticisms, or discussions pertaining to this or the other articles published in this series.

Extingüishing the Short A-C. Arc

Three articles are presented herewith, following a common introduction, all on the same general subject, namely, the extinction of the short a-c. arc at low voltages in air. The importance of this subject is emphasized by the increasing use of the low-voltage a-c. distribution network and of a variety of equipments for interrupting circuits in air.

SHORT ARCS are employed in all circuit interrupters operating in a-c. circuits of less than 150 volts, and also are made use of in the deion air circuit breaker, where many short arcs are placed in series for operation at high voltages. Of equal importance is the behavior of an arc during a short circuit in low-voltage a-c. cables. The low-voltage network which is finding such great popularity as a system of distribution in metropolitan areas is dependent upon the capacity which it enjoys for self-clearing of faults without interruption of the power supply. This system insures that at any point of fault there will be sufficient current to melt apart any contacting metallic conductors and start an arc, and the low voltage which has been used on most networks insures that the arc will be extinguished quickly at a normal zero of current.

The first article, that by Attwood, Dow and Krausnick, presents in considerable detail the results of a very comprehensive group of tests on the reignition of a-c. arcs in air for different rates of build-up of the circuit voltage across the arc space. Throughout their tests the arc was produced by a current of 25 amperes at 660 volts, 60 cycles between flat copper electrodes placed $\frac{3}{4}$ in. apart in air. Although a strict interpretation of their results must be confined to low-current arcs, the very large number of oscillograms which they carefully have taken, studied and presented, throw considerable light on exactly what happens during the extremely short period when the arc current is at zero.

The second article, by Browne, presents the results of a group of experiments on the more common types of stationary arcs with molten electrodes, for the purpose of determining the influence upon the arc characteristics of such parameters as electrode material, current strength, and length of arc. The third article, by Slepian and Strom, is concerned principally with the effect which cable insulation has on the extinguishing of faults in low-voltage a-c. networks, due to the deionizing action of gas blasts formed by the decomposing insulation.

The fundamental theory upon which all three of these papers are based is identical. The continuance of the a-c. arc is believed to depend upon repeated reignition for each new half cycle after a current zero. The extinction of the arc has been shown to depend upon the outcome of "a kind of race" between two opposing processes taking place within a very short period after the current reaches zero. The first is the building up of voltage across the arc space tending to cause the arc to reignite, and the second is the diminishing of the conductivity of the arc space, or the increasing of its dielectric strength, tending to prevent the arc from restarting. The first depends upon circuit constants and upon circuit conditions existing at the current zero, and so theoretically can be calculated according to well-known principles, although this may be rather difficult if the circuit is not sufficiently simple. The second process, and the one with which these articles are most concerned, depends upon the characteristics of the arc itself. These are exceedingly complex and as yet understood to only a very limited extent. This building up of dielectric strength depends upon conditions internal to the arc space, such as the nature and geometric arrangement of electrodes, the nature of the gas, presence of magnetic fields, and gas blasts.

According to the modern theory of conduction in gases, the rapid recovery of dielectric strength by an arc space immediately following a current zero must be due to the disappearance of the ions which are required for the conduction of the arc current. Ions disappear from the arc space by direct recombination in the arc space itself; discharge to the electrodes; recombination on surrounding walls or in surrounding cooler gases; recombination in cooler gases mixed turbulently into the arc space by gas blasts; and formation of an almost completely deionized layer adjacent to the cathode by the action of the ions of the growing impressed electric field. In short arcs, discharge to the electrodes appears to be most important, and in longer arcs, recombination on surrounding walls and gases. The importance of the gas blast in practical devices only recently has begun to be appreciated.

Although the theory upon which all three of these articles are based is identical, the terminology varies somewhat. Figs. 2 and 3 of the first article and Fig. 6 and 12 of the other two articles, all represent the increasing dielectric strength of the arc space as a function of time. This increasing dielectric strength is referred to by Attwood, Dow and Krausnick as the "reignition-time locus," while Browne does not coin

any special phrase to designate it. Slepian and Strom refer to this quality as the "arc reignition characteristic." The latter also refer to the tendency of the circuit to build up voltage across the arc space as the "circuit reignition characteristic."

The conclusions presented by these authors regarding the factors aiding arc extinction are most interesting, and in some cases striking. In general, they are in agreement, although the first two articles differ somewhat on the effect which length of arc has on the recovery of dielectric strength by the arc space; and the first article also indicates that the "reignition-time locus" should be represented as an area rather than as a curve. Whether or not these apparent discrepancies result from the fact that the first article considers arcs of relatively low current values, 25 amperes, while the second reaches into currents of a few thousand amperes, may possibly be explained by the further tests on short arcs which doubtless will be made in different laboratories.

I—Oscillograph Tests on Low-Current Arcs

By

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REIGNITION OF A-C. ARCS being dependent upon the arc-voltage relations during current zero, a study based on some 200 cathode-ray oscillograms has been made of the voltage and current relationships near the cyclic current zero in arcs between metallic electrodes.

For experimental purposes a 25-ampere 660-volt 60-cycle arc between flat copper electrodes spaced ¾ in. apart in air was utilized. The circuit used (see Fig. 1) consisted of a transformer of voltage e_s connected to the arc through a reactor L, with its small (but not negligible) distributed capacity C_L. The voltage e_a of necessity was measured by a cathode-ray oscillograph because of the extremely rapid variations. Time relations existing between the supply voltage e_s, the arc voltage e_a, and the arc current i_a are shown also in Fig. 1. During approximately 95 per cent of each half cycle the arc current is a sine wave lagging practically 90 deg. behind the supply voltage, while the arc voltage remains constant. It is upon the remaining 5 per cent of the half cycle that the major part of this investigation has been concentrated.

Eventually the arc current reduces sinusoidally to a small value I_1 (order of 0.1 ampere) at which value it suddenly fails, falling sharply to zero, where it remains until the arc again is made with current in the opposite sense. During this short period the supply voltage is practically constant ($e_s = E$).

The current i_L in the inductance cannot cease flowing instantaneously and therefore surges into the distributed capacity. During the period of current zero (from 0 to t_1) the voltage e_a may be computed by the usual circuit equations, which are shown also in Fig. 1. In the circuit used, L was 0.066 henry and C_L was 440 $\mu\,\mu$ f.; with these values a cosine voltage having a frequency of 29,400 cycles per sec. is set up across the arc terminals.

At time t_1 when the electrode voltage has reached a value of perhaps 400 volts in the positive direction, the arc space breaks down and the voltage drops rapidly to the glow value of 350 volts, remaining constant for a period varying from an extremely brief interval to several hundred microseconds. During the glow period (t_1 to t_2) the arc current rises slowly. At time t_2 when the current through the inductance has risen to a value sufficient to maintain an arc, the electrode voltage drops sharply from the 350-volt glow value to approximately 100 volts for the arc proper; the arc current then resumes its sinusoidal character. Particular attention is called to the negative dip in the electrode voltage. This dip is due entirely to failure of the arc current at some definite value prior to the time when it would become zero had it continued along its sinusoidal variation.

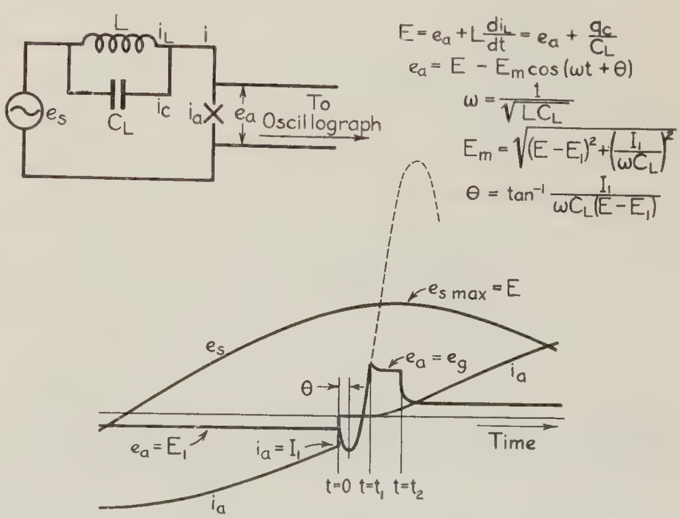

Fig. 1. Current-voltage-time relations for the unshunted a-c. arc. At the upper left may be seen a schematic diagram of the test set-up

From "Reignition of Metallic A-C. Arcs in Air," (No. 31-53) presented at the A.I.E.E. Middle Eastern District meeting, Pittsburgh, Pa., March 11-13, 1931.

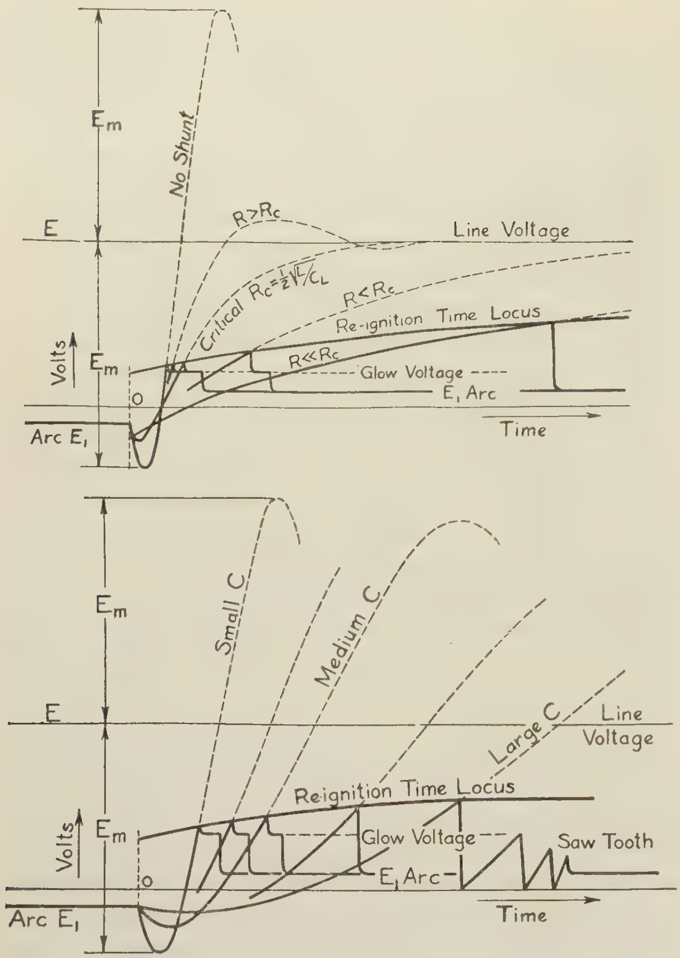

Fig. 2. Effects of resistance (above) and capacity (below) upon arc reignition time

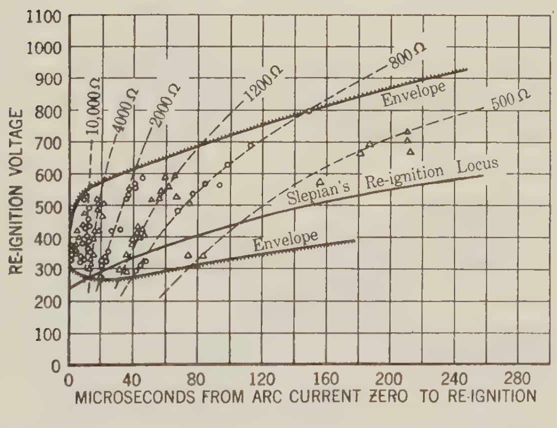

Fig. 3. Actual measurements of reignition voltage-time relations for various arc shunt resistances

If the arc electrodes are resistance-shunted, the circuit equations show that during the zero-current period, the rise of voltage across the electrodes will be slowed down materially. With more time available for deionization the electrode voltage must rise to a higher value in order to break down the arc region. The effect of varying this shunt resistance may be seen in Fig. 2.

The line drawn through the breakdown values may be called the *reignition-time locus*. This locus shows the rapidity with which the deionization process in the arc space proceeds during the zero-current period.

For an arc shunted by resistance greater than the critical resistance, the electrode voltage e_a may be computed from equation (1), which represents a damped sine wave.

$$e_a = E - e^{-\frac{1}{2RC_L}t}\left[(E - E_1)\cos\omega t + \frac{1}{\omega C_L}\left(-I_1 + \frac{E - E_1}{2R}\sin\omega t\right]\right. \qquad (1)$$

where $\omega = \sqrt{\frac{1}{LC_L} - \frac{1}{4R^2C_L^2}}$

$$R > \frac{1}{2}\sqrt{\frac{L}{C_L}}$$

For values of resistance less than the critical amount,

$$e_a = E - e^{-\frac{1}{2RC_L}t}\left[(E - E_1)\cosh\beta t + \frac{-I_1 + \frac{E - E_1}{2R}}{\beta C_L}\sinh\beta t\right] \qquad (2)$$

where $\beta = \sqrt{\frac{1}{4R^2C_L^2} - \frac{1}{LC_L}}$

$$R < \frac{1}{2}\sqrt{\frac{L}{C_L}}$$

For still smaller values of resistance equation (2) reduces to the simpler form of equation (3)

$$e_a = E - e^{-\frac{Rt}{L}}[E - (E_1 + I_1R)] \qquad (3)$$

For resistance shunts greater than the critical value it may be noted that the arc-voltage rise takes the form of a damped sine wave. For resistances smaller than the critical value, the voltage-rise curve is a hyperbolic function of the circuit constants and time, and is asymptotic to the line voltage E. The critical resistance proved to be 6,125 ohms for the circuit constants used in this study.

Equations shown in Fig. 1 apply also to the voltage and current relations in a capacity shunted arc if the shunt capacity C is used in place of the now negligible distributed capacity C_L. Inasmuch as C is usually much greater than C_L the cosine curves of electrode voltage rise are much slower than in the non-shunted arc. This point is illustrated in the lower part of Fig. 2.

In Fig. 3 are plotted the actual reignition voltage-time points as obtained from oscillograms for a number of different resistance shunts across the arc. The dashed curves indicate the voltage rise across the electrodes. Particularly worthy of note is that reigni-

tion may occur anywhere along the voltage-rise curve between the limits set by the upper and lower parts of the envelope. There is no single value of voltage at which reignition takes place, but a general upward trend with time is shown by the reignition envelope. A set of tests using capacity shunts led to the development of an envelope which is identical with the envelope shown for the resistance shunts.

Significance of the three regions into which the envelope divides Fig. 3 is perhaps most clearly explained as follows: when the rising electrode voltage is below the lower branch of the envelope, reignition cannot take place; inside the envelope region reignition may take place, but it invariably occurs by the time the upper envelope is reached. For a low-resistance shunt such as the 500-ohm case shown in Fig. 3 the electrode voltage may rise to the line voltage without reignition taking place. This has been observed frequently.

By using another method, Slepian (*Extinction of a Long A-C. Arc*, A. I. E. E. TRANS., Vol. 49, p. 421) obtained previously a reignition locus which is drawn on Fig. 3 for the sake of comparison. It is believed that his curve would coincide with the lower branch of the envelope if test conditions were identical.

Efforts to locate the cause of the variability of restriking voltage so far have been fruitless; it may be due, however, to the presence of impurities in the surfaces of the electrodes over which the arc moves, though ever so slowly.

In Fig. 4 are shown four cathode-ray oscillograms of the electrode voltage during the current zero period, each oscillogram showing a number of curves taken at least 20 cycles apart. These illustrate the changes occurring when the arc shunt resistance is varied. With a 10,000-ohm shunt the cosine voltage wave is much in evidence; with resistances below the critical value (6,125 ohms) the hyperbolic curve may be observed. The 1,200-ohm case shows a rapidly rising voltage with reignition occurring at a practically constant value, whereas in the 4,000-ohm case the voltage rise is much slower with a decided variability in the reignition values. With 0.1-μ f. shunt a cosine voltage rise may be seen with a somewhat variable reignition voltage. The "saw-tooth" voltage peculiar to a capacity shunted arc is caused by the alternate charge and discharge of the shunting condenser, and hence occurs only with relatively large values of shunt capacity.

In the 10,000-ohm case it may be noted that two types of negative dip may occur. A peaked negative dip indicates that the arc current failed at a slightly larger value than for the curved negative dip; the negative voltage then rose to a value sufficient to cause glowing before the real current zero period was reached.

Application of this material to the action of a circuit breaker as it opens, drawing longer and longer arcs for each succeeding half cycle, is illustrated in Fig. 5. Three electrode-voltage curves and three expected reignition loci are plotted for three successive half cycles.

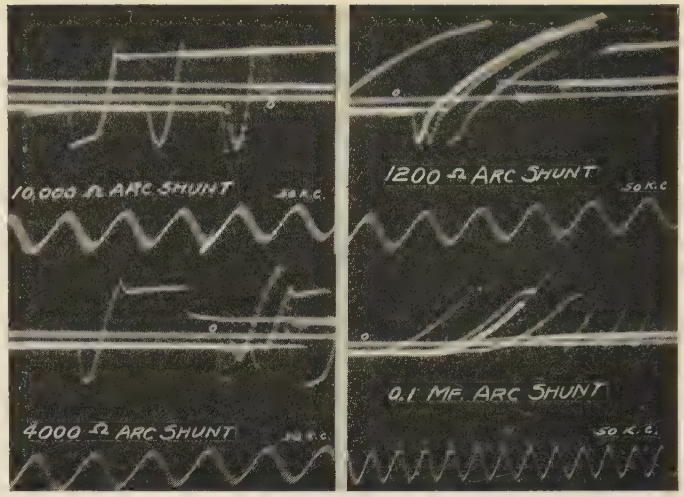

Fig. 4. Arc-voltage oscillograms with different arc shunts. (Critical resistance, 6,125 ohms)

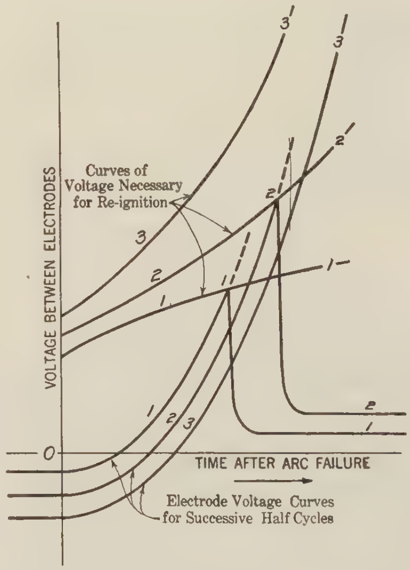

Fig. 5. Expected reignition voltage-time relations for capacity arc shunts with increasing electrode spacing, simulating the arc conditions which exist when a circuit breaker opens

Because the electrode voltage increases with increasing arc length, causing any given value of recovery voltage to occur at longer periods of time from the instant of arc failure, curves of this voltage start at different negative values.

The beginning points of the arc reignition curves are drawn higher for each succeeding half cycle because the greater electrode spacing should require a somewhat greater short-time value of breakdown voltage. The slopes of the arc reignition curves are made steeper for each succeeding half cycle because deionization should be expected to take place more rapidly with long than with short arcs. The crossing of curves 1, and again of curves 2, indicates successive half-cycle reignitions where the two curves meet. The fact that curves 3 do not intersect indicates that deionization has taken place with such rapidity that the voltage-rise curve never will meet the reignition curve and consequently, reignition no longer will take place.

It is thought that loads on a line located near a circuit breaker which opens will operate upon the breaker in much the same manner as the shunt resistances discussed previously, tending to cause a delay in the rise of electrode voltage toward reignition, with a consequent lessening of the expected severity of circuit-breaker duty. It should be emphasized, however, that Fig. 5 illustrates qualitative action only. Care should be taken not to generalize too far into high-voltage or large current situations from the results here described.

II—Various Factors Aid Extinction of Arcs

By
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EXPERIMENTS to determine the influence of such parameters as electrode material, current strength, and arc length on the characteristics of the more common type of stationary arcs with molten electrodes, have given results not previously expected. Simplified calculations made by Slepian a few years ago based on the theory that ions are lost from the arc space only by direct ion recombination, predicted a manner of recovery of dielectric strength substantially the same as that actually revealed by experiments made on cold electrode arcs at about the same time. The rate of recovery of voltage across the arc space following a current zero was controlled by shunting the arc with resistance, and the maximum allowable rate of rise of voltage was determined from the maximum value of shunting resistance at which the arc would just be extinguished after one-half cycle.

In general, the experiments recently completed show that the manner of dielectric recovery following a current zero of short, stationary a-c. arcs with molten electrodes conforms to the predictions of Slepian's theory and is similar to the recovery of rapidly moving cold electrode arcs previously investigated. That is, for electrodes whose boiling temperatures are below the temperature required for appreciable thermionic emission, the ability to withstand 100 volts or more was recovered within a few microseconds after a current zero, and further dielectric strength was regained at a very much lower rate. This is shown by the curves of Fig. 6.

From "Extinction of Short A-C. Arcs," (No. 31-90) presented at the A.I.E.E. summer convention, Asheville, N. C., June 22-26, 1931.

As predicted, the initial very rapidly recovered dielectric strength was found to depend solely on the electrode material and gas medium, and not at all on any other conditions within the limits investigated. The further more slowly recovered dielectric strength did not, however, prove to be independent of such conditions as arc length and current magnitude, as Slepian's approximate theory predicts that it should. This simply indicates that factors neglected in the simplified theory, such as diffusion of ions to the electrodes and to the surrounding air, the electric field, and temperature variations, are not actually negligible.

Effect of Arc Length

The effect of length of the arc on recovered dielectric strength was found to depend on the electrode material used. In the first series of tests made with brass electrodes, the effect of arc length was very striking and at first sight seemed paradoxical. As shown in Fig. 6, the dielectric recovery of a 0.158-cm. arc was considerably more rapid than the recovery of an arc of twice that length under otherwise similar conditions, indicating that the shorter arc is easier to extinguish than the longer. This effect is shown in a still more striking manner by plotting the initial slopes of critical applied voltage curves, like those shown dotted in Fig. 6, against arc length. This has been done in Fig. 7 for extinction at 450 volts, and shows that the effect extends up to five cm. or more, but is most pronounced at lengths of less than one cm. A similar but still more pronounced effect was observed with metals of lower boiling point than that of brass. With electrodes of the higher boiling metals, however, such as copper, iron, and tungsten, the effect was very much less and reversed its direction at the shorter lengths. This is illustrated by Fig. 8, which is the curve of Fig. 7 for brass, redrawn to a different scale and compared with similar curves for mercury, zinc, copper, iron, and tungsten-electrode arcs. The curves for copper and

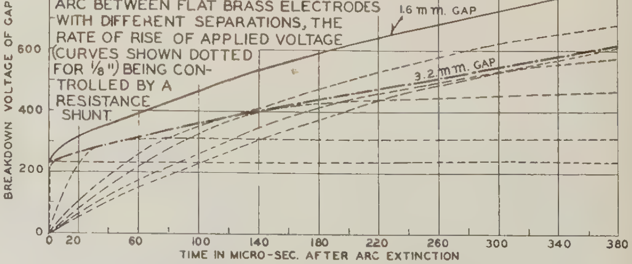

Fig. 6. Rate of recovery of dielectric strength of arc space immediately following a current zero

iron are seen to coincide practically with that for brass near five mm. and above and to exhibit the same falling characteristic above about four mm.; but below this length, instead of rising rapidly with diminishing length as with the lower boiling metals, they fall off again; the curve for iron rapidly approaching zero and the curve for copper falling and then apparently tending again to turn upward at the shortest lengths investigated. With the very refractory metal tungsten, the curve is much lower even than with copper and iron, but still appears to reach a maximum at some arc length less than one cm. and to fall off with increasing length above that.

Effect of Electrode Material

As already shown, the behavior of a short a-c. arc depends very largely on the material of the electrodes. Fig. 9 shows the results of a series of experiments on 300-ampere, 60-cycle, 450-volt arcs, 0.079-cm., 0.158-cm., and 0.316-cm. long, using various metallic elements as electrodes. The critical initial rate of rise of voltage as measured by the critical shunting resistance for arc extinction is plotted in each case against the boiling point of the element. The interesting and surprising feature of this graph is the definite tendency for the points at each arc length to fall on intersecting straight lines. This approximately linear manner of variation with boiling point applies to all the metals for which results were obtained except mercury, which has values at about twice those required to fit the straight lines, and magnesium, aluminum, manganese, molybdenum, and tungsten (not shown), which either form stable refractory oxides or themselves boil at high enough temperatures for copious thermionic emission, thus preventing the immediate recovery of dielectric strength which characterizes the non-refractory metal arcs.

The performance of aluminum, copper, and brass-electrode arcs is shown comparatively in Fig. 10, in the form of curves of critical initial rate of rise of reestablished voltage plotted against the effective circuit voltage at which the values were obtained, other conditions than voltage remaining the same. Remembering that the ordinates of any one of these curves may be considered as a measure of the speed with which the arc space regains the ability to withstand voltages equal to the maxima of sine waves having the effective values given by the abscissas, it may be seen that 0.158-cm. arcs with aluminum electrodes require a very much longer time to recover ability to withstand a given voltage than do arcs of similar length between copper electrodes, and that 0.158-cm. copper-electrode arcs in turn recover dielectric strength very much more slowly than do 0.158-cm. brass-electrode arcs, other conditions being equal. The rapid rise of all of these curves at the lower voltages is attributed to the approach of the maximum voltage values to the minimum dielectric strength of the cathode-space charge sheath, which is recovered in practically zero time. This initially-recovered dielectric strength is approximately 160 volts

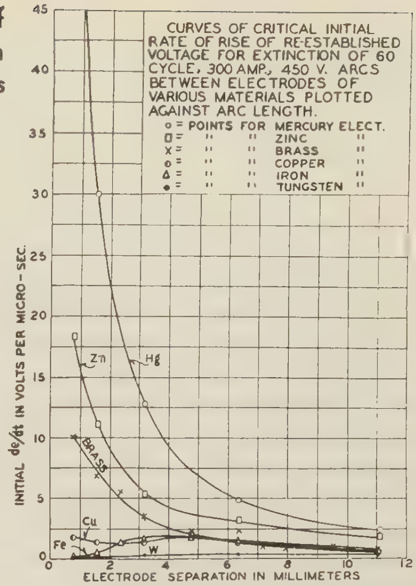

Fig. 8. Effect of electrode separation on arc characteristics

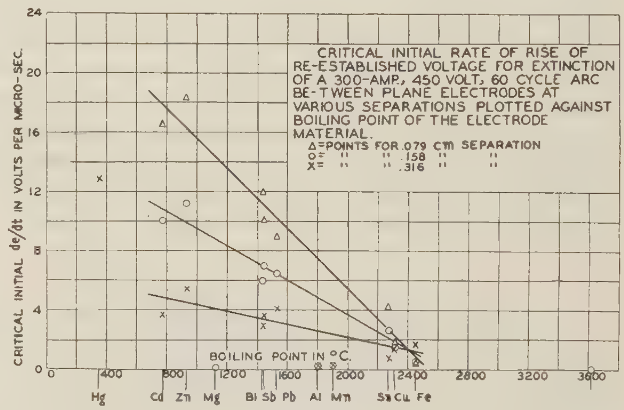

Fig. 9. Effect of boiling point of electrode material on arc characteristics

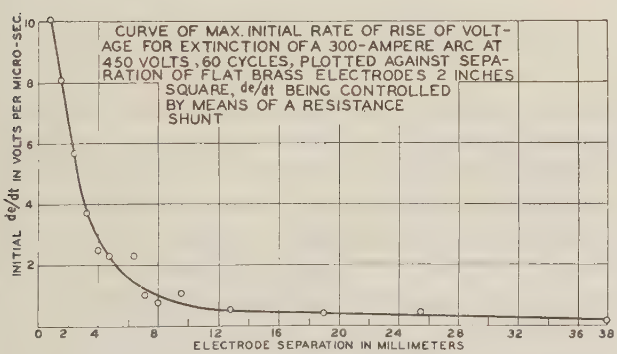

Fig. 7. Initial slopes of critical applied voltage curves for extinction at 450 volts

(maximum) for both copper and aluminum arcs, but is nearly 230 volts for brass-electrode arcs. Because of the scale used, the upper portions of the curves for copper and brass are not shown in this figure.

Effect of Current Magnitude

The simplified theory already referred to, predicted that the dielectric recovery of a short arc space should also be independent of magnitude of the arc current, but this prediction depended on the assumption that ionic diffusion to the surrounding air is negligible, which can be true only if the diameter of the arc is large in proportion to its length. Even for arcs only 0.158 cm. long, this condition is approached only at currents of more than a thousand amperes or so; therefore independence of current magnitude may be expected only with currents of this order. Fig. 11 shows this to be the case for a 0.158-cm. copper arc at 450 volts; current variations produce little change in the rate of dielectric recovery above 1,500 amperes, but below this value, decreasing the current causes a rapid increase in speed of dielectric recovery. Below about 150 amperes, the behavior of the arc becomes increasingly erratic so that definitely consistent values of a critical initial de/dt were very difficult or quite impossible to determine. Tests made by F. C. Todd with the cathode-ray oscilloscope show that the restriking voltage of continually restriking arcs is extremely variable when the current is as low as 90 amperes.

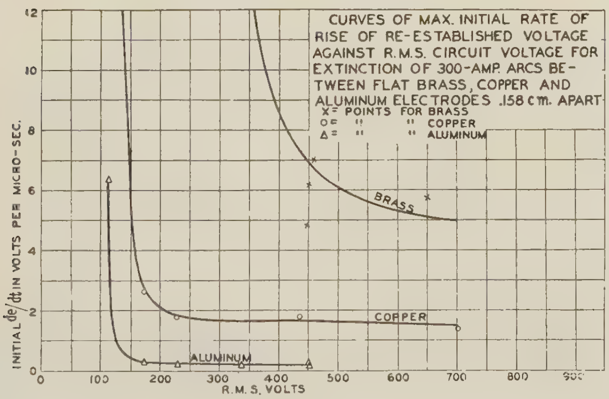

Fig. 10. Effect of circuit voltage on arc characteristics

Application to Engineering Practise

In view of the results herein presented, some suggestions may be made with regard to the construction of low-voltage circuit interrupting apparatus, where extinction of low-voltage a-c. arcs resulting from faults is important. Because of the marked superiority in short arcs of brass electrodes over copper or aluminum electrodes with regard to speed of recovery of dielectric strength at current zero, it would seem advisable to use brass for the contact-breaking parts of low-voltage switches working near their limit.

The suggestions in regard to the use of brass, copper and aluminum may apply with even more force when considering a material for conductors in secondary distribution networks than they do to switch construction. Thus it is suggested that the permissible operating voltage of such networks might be raised if brass conductors were used. These results, however, must be interpreted with caution when applying them to a problem having such varied practical aspects. Where the conductor material would also act as the electrode in case of a fault, it should be noted in Fig. 8 that the difference in favor of brass over copper applies only when the length of the arc is less than 5 mm. Consequently, if the arc would usually be longer than this, brass would probably be no more effective than copper or aluminum in aiding its extinction.

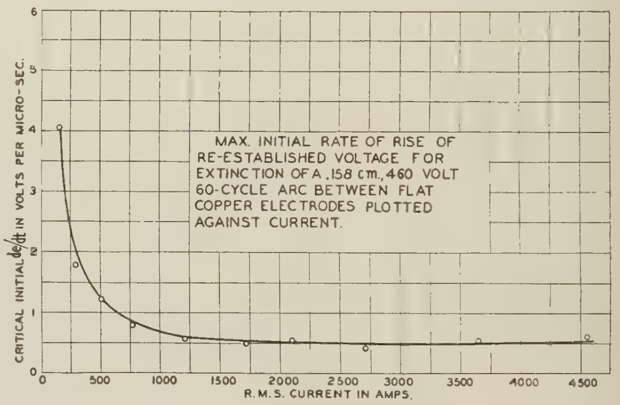

Fig. 11. Effect of current magnitude on arc characteristics

It may be noticed, also, that there is a discrepancy between practical experience with faults in secondary networks and the results given here, in that faults commonly are cleared on networks as high as 230 volts r. m. s. whereas in the laboratory, high-current copper-electrode arcs 0.158 cm. long could be easily maintained at as low as 113 volts. This may be due to less severe circuit conditions in the case of the practical network, caused by a fairly high power factor on short circuit and the presence of distributed capacitance of the cables and of shunting resistance in the form of connected lighting load, all of which tend to decrease the rate of recovery of voltage across the arc space at a current zero and so allow time for deionization of the arc and recovery of dielectric strength. Probably of more importance, however, is the deionizing action of gases resulting from burning of the cable insulation, the action of which is similar to that of gases from the decomposing oil in an oil circuit breaker.

III—Insulation Material Aids Extinction of Cable Arcs

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A CLOSE STUDY of the type of arcs occurring with faults in low-voltage a-c. networks and the method by which they are extinguished has brought out several striking conclusions. It has been found that short arcs between copper electrodes and not adjacent to insulation are inadequate to meet the fault-clearing requirements of low-voltage a-c. networks of more than 130 volts. Actual low-voltage networks of voltage higher than 130 depend for extinction of arcs upon the strongly deionizing action of gas blasts coming from decomposing adjacent insulation. As suggested by this result, it has been found also that the extinction of arcs in cables is strongly affected by the closeness of the insulation to the arc. Also, inorganic insulating materials giving off non-combustible gases have been found to be effective in aiding arc extinction, and of the various inorganic materials tried, boric acid was the best. Further, where organic insulation has been charred, it may be expected to lose its property of aiding arc extinction.

The Short Arc Without Gas Blast

Test curves of the recovered dielectric strength of the arc space, or "arc reignition characteristic," are shown in Fig. 12. It will be noted that up to a certain point there is an almost instantaneous recovery by the arc space of dielectric strength; after that the recovery of dielectric strength is much slower. Curves *A*, *B*, and *C* indicate that the immediately recovered dielectric strength is independent of the arc length. As shown by curve *C*, the slope was found to decrease with an increase of arc length. Curve *D*, however, indicates that for heavier currents there is an extremely low value of immediately recovered dielectric strength, and an extremely small slope of the characteristic for the first few hundred microseconds.

Earlier tests made by Kehoe indicate that the arc following a fault in an a-c. network cable will always be extinguished at 220 volts r. m. s. At 1,000 volts r. m. s., currents up to 500 amperes, and at 2,000 volts r. m. s., currents up to 100 amperes were also successfully interrupted by the arc. Although the tests at higher voltages were not conclusive, it appeared certain that at 220 volts the arc would be extinguished under all circuit conditions. These, and the results of other similar tests, are entirely compatible with the earlier data on arc reignition characteristics, such as curves *A*, *B*, and *C* of Fig. 12.

The more recent results indicated by curve *D*, and which should be more directly applicable to cable-fault arcs, are not compatible with these results. According to curve *D*, arcs with currents exceeding 1,200 amperes would not be extinguished with more than 125 volts or 130 volts r. m. s. in a low-power-factor circuit. We are then driven to the conclusion that in a-c. cable-fault arcs there must exist additional deionizing agents which are not active in ordinary short arcs between metal electrodes.

These additional deionizing agents must come from the insulation used in cables, and the authors believe that it comes from the intense blasts of gas directed to the arc from the adjacent decomposing insulation. This turbulent inpouring of fresh, relatively cool, un-ionized gas from the decomposing insulation may well cause the extinction of the arc in circuits of voltage higher than otherwise would be possible. Gases which are inflammable and under certain circumstances even may constitute an explosion hazard, are probably necessary in the functioning of low-voltage a-c. networks.

Tests on Arcs in Cables

Further substantiation of the important part insulation plays in the extinction of the arc, and an indication of the persistency of the arc when not subjected to the influence of insulation, was shown in a number of copper-to-copper short circuits made in short lengths of oil-impregnated paper-insulated cable. The cable used was 600-volt, three-conductor, 500,000-cir. mil lead-covered cable manufactured by the Habirshaw Cable Company. The arcs were started in several different ways, and were made in a 550-volt r. m. s. 60-cycle circuit in which the current was limited only by

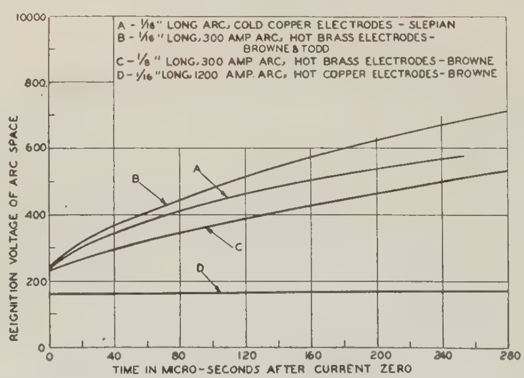

Fig. 12. Test curves of arc reignition characteristics

From "Arcs in Low-Voltage A-C. Networks," (No. 31-54) presented at the A.I.E.E. Middle Eastern District meeting, Pittsburgh, Pa., March 11-13, 1931.

the reactive impedance of the transformers and cables. Currents varied from 3,000 to 10,000 amperes. In some of these tests the short circuit was made near the end of the cable opposite the power supply, and in others near the middle of the cable section, power being supplied from both ends to eliminate the strong magnetic blowout effect that is present with the first method of short-circuiting.

In general it was found that when the arc was closely bounded by insulation it would be extinguished in from one to fifteen half cycles. Occasionally, however, the arc would persist, and it was then found that placing resistance in shunt with the arc having a value as low as one ohm, had no influence on the extinction of the arc. In those tests where the insulation had been carefully cleaned away about 6 in. or more from the arc, the arc would then persist, and the arc voltage was about 350 volts, or three or four times as large as when the arc was bounded closely by insulation. This value is very much too high for an arc drawn in air and unexposed to any gas blasts. The only conclusion which can be reached is that it was caused by the decomposition of the insulation.

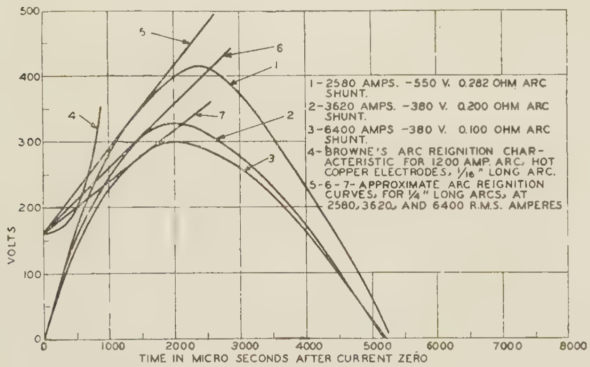

Fig. 13. Calculated circuit reignition characteristics are given in curves 1, 2, and 3

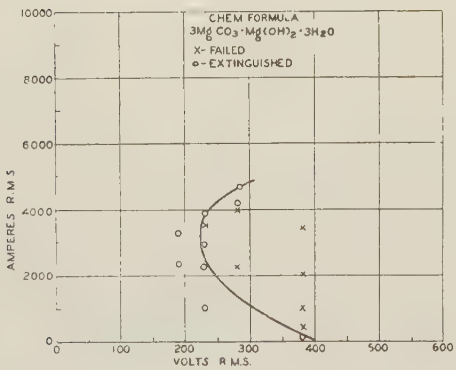

Fig. 14. Arc extinguishing properties of basic magnesium carbonate

Tests on Arcs Between Copper Plates

Definite confirmation of the importance of the decomposing insulation in extinguishing arcs, as well as quantitative results on both organic and inorganic insulation at heavy currents were obtained in a group of short-circuit tests made between a pair of copper plates. These were ¼ in. thick and 4 in. by 27 in. in area, spaced about ¼ in. apart. To keep the gas pressure between the plates low, ½-in. holes, spaced 1.41 in. between centers, were punched in the plates.

Tests were first made using only an air-gap between the plates, and values were determined for resistance which when in shunt with the arc would just cause it to go out. With these values the circuit reignition characteristics should be just tangent to the arc reignition characteristic. Three calculated "circuit reignition characteristics," or tendency of the circuit to build up voltage across the arc space are shown in Fig. 13, in which curve *D* from Fig. 12 is redrawn, and three probable arc reignition characteristics for the larger currents and spacing are indicated by curves from the 160-volt point on the voltage axis tangent to the various circuit reignition characteristics.

Arc potentials in these tests were found to vary from 40 to 100 volts, and it was shown decisively that the simple short arc between copper electrodes free from insulation is inadequate to meet the fault-clearing requirements of low-voltage a-c. networks.

Further tests were made with the same electrode arrangement but with oil-filled paper clamped between the copper plates, the fuse for starting the arc being passed through a ⅛-in. hole in the paper. At 550 volts the arc was extinguished for all values of current tried, up to 11,000 amperes. Similar results were obtained as the voltage was increased to 750, although at 1,150 volts the arc persisted. The arc potential was found to vary from 300 volts at low currents to 600 volts for high currents. Increasing the size of the hole to ⅜ in. caused the arc to persist at 550 volts, and the arc voltage was only about 200 volts. Tests in which the paper was impregnated with vaseline and with glycerine gave results practically the same as for the oiled paper, and the important part played by the insulation in the extinction of cable arcs was again affirmed.

Preliminary tests were then made using inorganic insulation which would give off incombustible gases such as water or carbon dioxide. The various materials in the form of powder were packed between the copper plates, and tests were then made as before. The arc was permitted to make as large a hole as it would in the closely packed, powdered material.

The results shown in Fig. 14 for basic magnesium carbonate are typical of the relation between the current and the voltage that can be interrupted by a given length of arc. As the current is increased from small values, the volts which can be interrupted, decrease,

reach a minimum, and then increase again. This relation is rather to be expected if it is recalled that for very large currents the gas blast will be very intense, and that for very small currents the arc will be particularly sensitive to deionizing influences.

If, now, the voltage of the circuit is kept constant and only the circuit reignition characteristic is altered, similar results are obtained. Below a certain "speed" of circuit all currents are interrupted, whereas for higher "speeds" there will be an intermediate range of current for which the arc will persist.

This is illustrated in Fig. 15 which shows the results of tests using gypsum powder. All these tests were at 550 volts, with varying values of resistance shunting the arc to give different circuit reignition characteristics. For shunting resistances of less than 16 ohms, the arc interrupted all values of current; but for resistance greater than 16 ohms, there would be an intermediate range of current for which the arc would persist.

Because it so happens that most of the data for the different powders were obtained at 550 volts with varying resistance shunts, their efficacy may be compared by plotting in one figure several curves similar to that of Fig. 15. This has been done in Fig. 16. No curve is given for boric acid, as the arc interrupted all values of current even when unshunted, except for one test which did not repeat itself. The curve for gypsum is taken from Fig. 15, and consists of the boundary of the region of arc persistency. The other curves were obtained in a similar manner.

From all these data it is concluded that boric acid made the best arc-extinguishing powder, being as good as oiled paper over the range of these tests. The next, although considerably inferior, is gypsum. Then far inferior, though better than plain air, are the rest of the materials tried.

Arc-Extinguishing Substances

From these tests it will be noticed that some requirement other than the amount of gas generated for a given volume, or for a given energy input from the arc, must be taken into account. This other factor probably relates to the state of the surface of the bounding material just after the moment of arc extinction. Even though the arc will not reignite in the arc space itself, the surface of the bounding material must be able to withstand the voltage without breaking down. Organic insulation in general seems to meet this requirement, as the surface remains clean and is of good insulating quality.

Ammonium carbonate, however, melts below the temperature at which rapid decomposition takes place, and the surface of the material which is left after a half cycle of arcing undoubtedly consists of a molten film of the ammonium carbonate which is highly conducting. A considerable current flows in the molten surface film, and the resultant tearing of this film while carrying current will restart the arc. Although boric acid also has its melting point below that at which rapid decomposition takes place, the electric resistivity of the molten boric acid is very high. The current will be so small that the power will be insufficient to keep the boric acid film hot, and it will recongeal, thus permanently opening the circuit.

While organic insulation in general has the property of being left with a surface of good dielectric quality after exposure to the arc, it may not have this property after it has been subjected to a moderately high temperature, so that it is more or less charred before the arc begins to act upon it. Insulation which has become charred for any reason is ineffective in causing the extinction of the arc, because it has lost its more volatile constituents and because after exposure to the arc, the surface which is left is almost entirely free carbon and a good conductor while hot. With normal organic insulation, the rapid evolution of gas seems to scour away the surface and keep it clean of carbonaceous residues; but the charred insulation has lost this property.

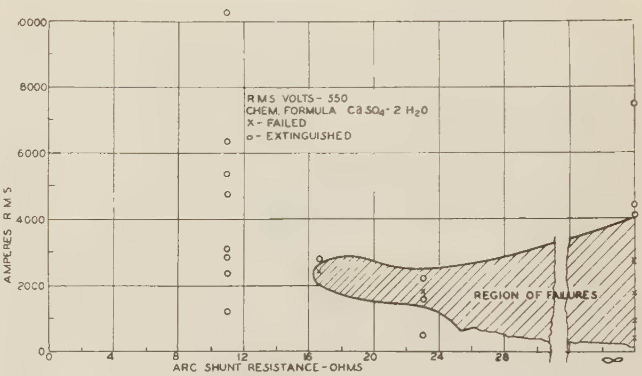

Fig. 15. Arc extinguishing properties of gypsum

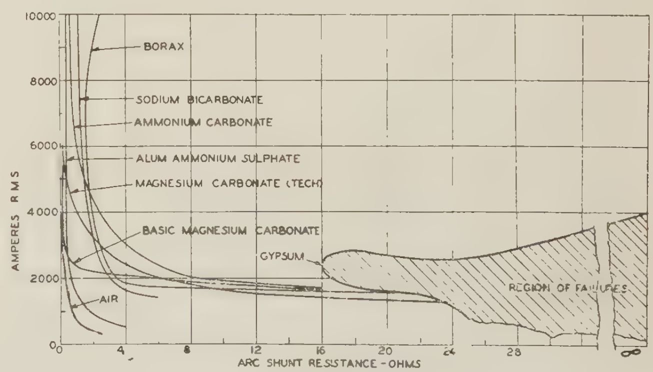

Fig. 16. Arc extinguishing properties of various powders

The Philadelphia A-C. Network System

Because several of its basic features differ quite radically from other distribution networks, the engineering plan of the Philadelphia a-c. network is outlined and five years' operating experience is summarized.

By
H. S. DAVIS
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Both of the Philadelphia (Pa.) Electric Company

THIS SYSTEM at present comprises 24 sectionalized primary loop feeders supplying three separate fused secondary networks areas totaling 1.26 sq. mi. The total 1930 peak load of the central business district of Philadelphia amounted to 72,820 kva., of which the a-c. network system carried 27,600 kva. and the remaining d-c. system 6,000 kw. The remaining 39,220 kva. is fed generally in large blocks at 2.3 or 13.2 kv. Supply for the whole area comes principally through four substations which in turn are fed from two steam-electric generating stations located about 1½ mi. away.

Each network area is fed by four primary loop feeders from each of two substations. These feeders are composed of three-conductor, 350,000-cir. mil paper-insulated lead-covered cable now operating at 2.3 kv., three-wire, two-phase, but designed for ultimate three-phase operation at 13.2 kv. Each feeder is routed through widely separated parts of its network area, interlaced with other feeders, and carried through several intersections to return finally to the substation of its origin. The several "unit-sections" of each primary loop are joined through 400-ampere 15-kv. subway-type oil circuit breakers subject to the control of the balanced pilot-wire protection scheme. For a standard 2-OCO-duty cycle at 2.3 kv. these breakers have a rupturing capacity of 30,000 amperes.

Network distribution transformers are all 100-kva. subway-type units of standard impedance. Most of them are constructed with the high-voltage winding in six sections, connected in parallel for present 2.3-kv. operation and permitting series connection for possible future operation at 13.2 kv. All of these transformers are installed in manholes usually four in a group together with one oil circuit breaker, two pilot cable junction boxes, and four low-voltage sectionalizing boxes. Barrier walls are not used in these manholes, but all (except control) cables are fireproofed.

The secondary a-c. network system is a grid of two-phase, five-wire 115-230-volt mains. This grid is fed from the primary loops through transformer banks placed at each main street intersection. To provide automatic isolation in cases of trouble the secondary mains and transformer leads are equipped with copper link fuses. These fuses are installed in five-way, single-polarity sectionalizing boxes to which the four secondary mains and the transformer leads are connected. Fuse capacities used are 1,250 amperes for mains and 1,500 amperes for transformer leads.

In the secondary network 350,000-cir. mil, 600-volt, paper-insulated, lead-covered cables are used. Single-conductor cables from the fused sectionalizing boxes may be spliced to single- or multiple-conductor mains. In many instances the three-conductor cables of the former d-c. network were used for one phase and two single-conductor cables installed to complete the system of two-phase mains. Present practise is to install single-conductor cable for the phase wires and a 2/0 bare neutral wire.

Both lighting and power loads are fed from the same set of secondary mains. No auto-transformers are required on the secondary network because the system conforms to accepted voltage standards for both light and power. Thus all parts of the system may be paralleled at will. It is of interest, too, to note that two-phase motors up to 40 hp. are taken on any part of the network, when well established, without requiring current-limiting devices for starting.

Operating Experiences

In general, five years' operating results with the Philadelphia network system have been satisfactory. Some of the more important operating experiences are outlined briefly in the following paragraphs.

1. In one case, trouble in a generating station cut off the power supply to a pair of substations feeding one of the network areas, dropping a 5,000-kva. load. Service was restored promptly, however, by resorting to the use of interstation tie lines. This enabled one of the dropped substations to pick up the whole area load during the emergency period.

2. In the second of two instances where system disturbances affected network areas, no service interruption occurred. In this case the 13.2-kv. transmission feeders to one of a pair of network-area substations were lost successively, dropping the entire area load of about 6,000 kva. on the second substation. This second substation thus carried for the emergency period all of its own load, the whole network-area load, and (through feedback) several important radial feeders from the first substation.

From "The Philadelphia A-C. Network System" (**No. 31-56**) presented at the A.I.E.E. Middle Eastern District meeting, Pittsburgh, Pa., March 11-13, 1931.

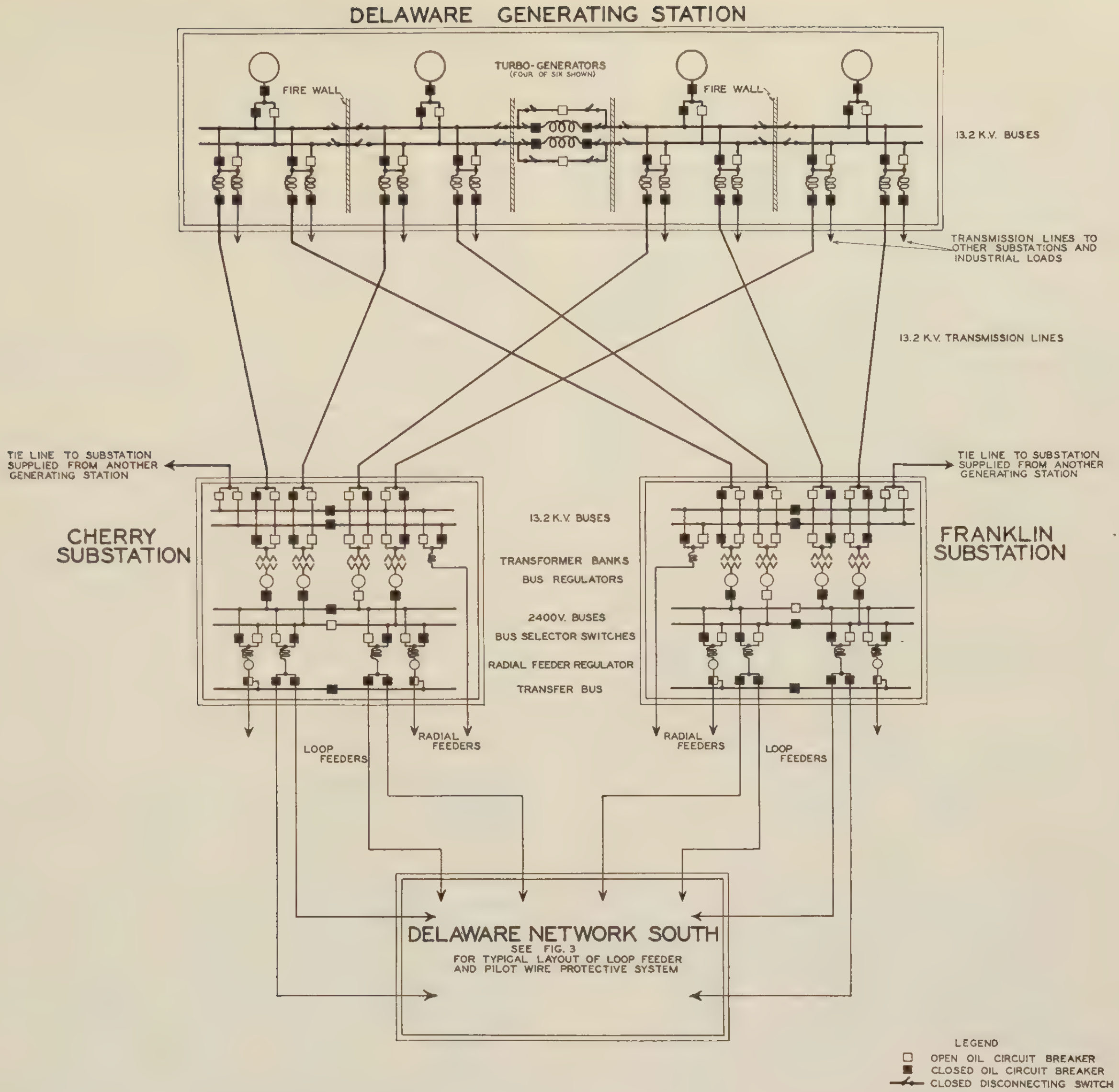

Fig. 1. Schematic diagram of typical power supply to a Philadelphia a-c. network area

Careful scrutiny of this diagram will reveal many details supplementing the accompanying text

Table I—Data Pertaining to the Philadelphia A-C. Network System—1930 Peak

		Delaware north	Delaware south	Schuylkill south	Totals December 1930
1.	Area in square miles operating network	0.413	0.467	0.376	1.256
2.	Maximum demand in kva. (network only)	8,023	9,897	9,682	27,602
3.	Number primary loop feeders	8	8	8	24
4.	Total normal capacity of loop feeders	10,620 kva.	9,600 kva.	12,320 kva.	32,540 kva.
5.	Average normal load per loop feeder	1,003 kva.	1,237 kva.	1,210 kva.	1,150 kva.
6.	Total length of loop feeder cable	70,400 ft.	99,800 ft.	92,400 ft.	262,600 ft.
7.	Average length per loop feeder	8,800 ft.	12,475 ft.	11,550 ft.	
8.	Total length of loop feeder cable between substation and first transformer bank	17,160 ft.	36,698 ft.	30,240 ft.	84,098 ft.
9.	Total length of loop feeder cable between substation and boundary of network area		21,292 ft.	6,805 ft.	28,097 ft.
10.	Number of unit sections on loops	57	70	72	199
11.	Average loop section length in feet	1,230 ft.	1,430 ft.	1,280 ft.	1,320 ft.
12.	Number of primary oil circuit breakers	49	62	64	175
13.	Installed transformer capacity kva	12,500	13,600	15,400	41,500
14.	Number of transformers (100 kva.)	125	136	154	415
15.	Number of transformer manholes	41	54	56	151
16.	Ratio normal loop feeder capacity to transformer capacity	85%	71%	80%	78%
17.	Ratio maximum coincident feeder demand to transformer capacity	64%	73%	63%	66%

3. Some 22 cable failures and three transformer failures have been isolated successfully without interruption to service in any unit-section other than that directly affected, and without impairing service to any customer. Cable failures have averaged one per 34 unit-sections per year, or 12 per 100 mi. of operating cable per year, the relatively high average being due largely to external mechanical injury. Transformer failures were caused by water leakage and consequent insulation breakdown.

4. The first consignment of oil circuit breakers caused trouble by tripping out from vibration, a trouble relieved by proper mechanical corrections. Excepting one other instance—a failure caused by water leakage—these breakers have given satisfactory service and have required only a minimum of maintenance.

5. The operation of fuses in these network areas has demonstrated that secondary faults are quickly and selectively isolated, and that the sizes used are satisfactory. There have been no cases of fuses blowing when a fault did not exist in that particular section. When fuses have not blown, faults have cleared themselves; in two cases they burned clear within a few inches of the point of origin.

6. In the pilot-wire relay system field inspections to date have disclosed three cases of failure in the four-conductor (No. 4) rubber-insulated, lead-covered cable. Also two cases of incorrect cable connections and one defective current transformer were discovered. However, none of these six irregularities caused circuit-breaker operation.

An inspection is made every three months by a group of five men to determine the condition of all equipment associated with the network. It is expected that with further operating experience the frequency of inspection may be reduced safely. In detail the inspections consist of:

1. Testing transformers, oil circuit breakers, and fuse boxes for water-tightness. The work involved in making equipment water-tight accounts for most of the inspection time.

2. Testing the entire pilot-wire relay system for grounds, open circuits, and short circuits.

3. Checking sensitivity of trip coils and operating mechanisms.

4. Looking for blown fuses and open secondary cable mains in the sectionalizing boxes.

5. Minor repairs and adjustments to all equipment as required.

Open breakers on the primary loop circuits are checked (1) by recording the hourly ammeter reading on each loop feeder, (2) by twice each week opening alternately the loop feeder ends, and (3) checking the approximate total currents under these test conditions. The current readings on each loop-end often indicate an open section and its approximate location.

Consistency in a Ten-Year Plan

Since the first Philadelphia a-c. network area was established in 1926 as an integral part of a ten-year program of changing the downtown business district from d-c. to a-c. distribution, the system plan initially adopted has been followed without fundamental change, and has proved amply flexible to meet changing load conditions. With the aid of an a-c. "system calculating board" the proposed system was laid out in detail to meet the general requirements:

1. That the network system as a whole should have sufficient spare capacity to insure against overloading any equipment during periods of unit-section or transformer outage; and

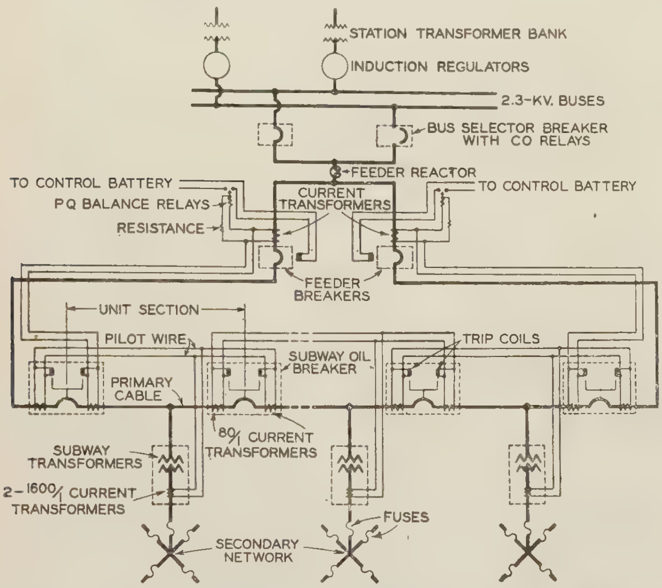

Fig. 2. (Above) Single-line diagram of pilot-wire relay protection system for a typical primary loop

It may be noted that only one transformer bank and associated cable is isolated in the event of a fault on the primary loop feeder

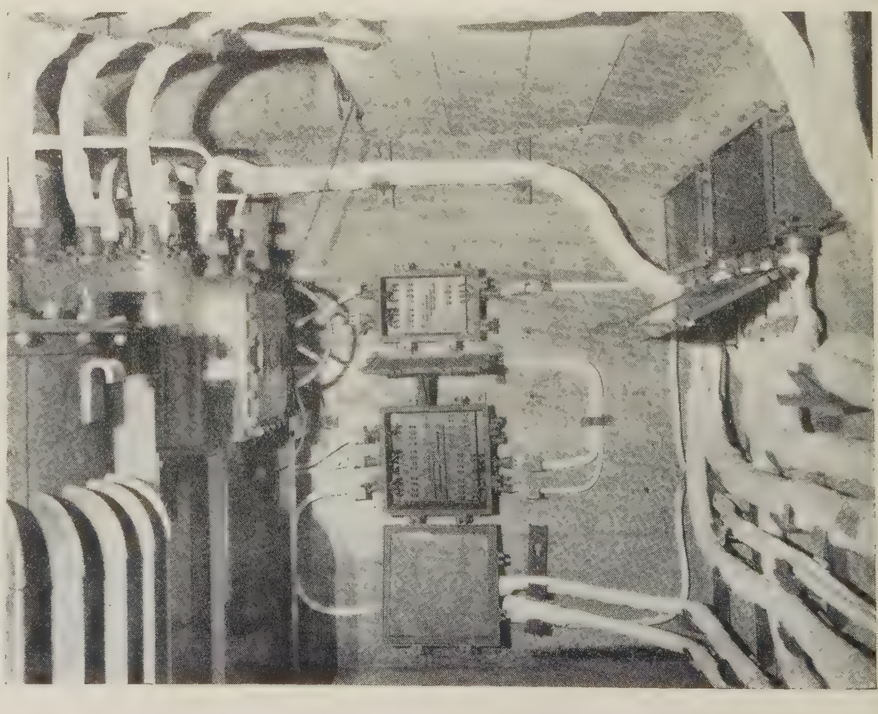

Fig. 3. (Right) Typical transformer manhole showing—left to right—transformer, oil circuit breaker, pilot cable junction boxes, and secondary sectionalizing boxes

Most manholes are 15 x 9 ft. in plan with 8-ft. headroom, and are located in the highway beneath the sidewalk. Two openings are covered by removable slabs, one of which has an open-grating lid and two openings for ventilating ducts which ducts extend from street surface to bottom of the manhole at each end

2. That adequate network voltage should be maintained under all conditions, including short-time (30 min.) loss of one of the two substations supplying any given area.

Both of these requirements have been proved in practical operation.

Synchronous Machine Constants

COMPANION papers "Calculation of Synchronous Machine Constants" by L. A. Kilgore and "Determination of Synchronous Machine Constants by Test" by S. H. Wright (see footnote) both of the Westinghouse Electric & Manufacturing Company, have been presented before the A.I.E.E. Until recently the theory of synchronous machines has required relatively few constants; a single value of reactance, usually called armature leakage, has been used to calculate the initial short-circuit current, and standard decrement curves have been applied to determine the rate of current decay. However, the need for greater accuracy in short-circuit and stability calculations has brought into quite general use the new theory involving symmetrical components. The various reactances and time constants affecting transient characteristics must be known in applying the new theory, and consequently there is a real demand for knowledge of these constants.

The paper by Mr. Kilgore presents a method of calculation for all the more important constants, except the subtransient time constant. The principle of superposition is applied to resolve the reactance accurately into components which can more readily be calculated. The induced current in the field and additional damping circuits are accounted for in a simple manner by applying the constant interlinkage theorem. Comparisons of test and calculated values are given, and formulas for the constants of both salient-pole and turbine generators are derived in the appendix.

Every designer of large synchronous machines has to meet this problem of calculating the constants and those who use the constants in other applications also are interested in knowing how accurately they can be calculated. Their application rather than their calculation has been the subject of most of the previously published information.

The paper by Mr. Wright, discusses the results of an investigation including extensive tests of the constants of various synchronous machines representative of those found in modern hydroelectric or steam-electric power systems. Although there is as yet no accepted set of definitions which standardize the meaning of these reactance constants, time constants, and resistances, they are discussed from a practical standpoint and methods for their determination from tests are described. Also are given details of the application of these methods to an extensive group of tests actually made.

These tests show the importance of such factors as saturation in the analysis of machines operating under short-circuit conditions. Saturation was found to be particularly important for turbine-generators, due largely to the inherently low reactance and therefore high short-circuit current of this type of machine. As a result, variations in some of the constants were found and are presented in the paper. The author advocates that unless otherwise qualified, reactances and time constants should be based on what are termed "saturated" values. Based upon the extensive tests performed, tables are given to show the values of the constants for various types of machines. These afford means of estimating the characteristic constants of the various synchronous machines that are found on the power systems of today.

Abstracted from "Calculation of Synchronous Machine Constants" (**No. 31-105**) by L. A. Kilgore, and "Determination of Synchronous Machine Constants by Test" (**No. 31-114**) by S. H. Wright, both presented at the A.I.E.E. summer convention, Asheville, N. C., June 22-26, 1931.

Field Transients in Magnetic Systems

MAGNETIC CIRCUITS generally are composed of magnetically different materials which have different characteristics such as magnetization curves, electrical conductivities, and thermal properties. The most important distinction, however, lies in the use of laminated and solid iron parts, both of which show extreme behavior in the case of transient phenomena. When any change of the associated magnetic field takes place, eddy currents are produced in the iron, and these eddy currents produce a reacting magnetic field. This condition delays the rate of change of the resultant field. In the case of laminated iron parts, the very structure of the system limits the amount of eddy current to a negligible value. However, the delay of the growth of the magnetic field in solid iron parts is one of the most important factors in the operation of many types of electrical equipment.

Previous solutions of this general problem have been based upon special assumptions which do not take

Abstracted from "Field Transients in Magnetic Systems" (**No. 31-115**) by E. Weber, presented at the A.I.E.E. summer convention, Asheville, N. C., June 22-26, 1931.

accurate account of the interlinkage of eddy current and exciting current. Ernst Weber in an A.I.E.E. paper (see footnote) presents a complete mathematical solution of suddenly applying a d-c. voltage to an electromagnetic circuit composed of an electric coil with a partly laminated and partly solid iron core containing an air-gap. Starting from Maxwell's field equations for the eddy current and the magnetic field in the iron core, the solution of the time conditions is reached with the aid of Heaviside's operational calculus. The result is expressed by means of a time constant of the magnetic field, composed of the time constant of the electric circuit and a fraction of a newly defined time constant due to the eddy currents in the iron part. The influence of the various dimensions of the solid iron part on the rate of change of the magnetic field is shown quantitatively. The results of the method described are illustrated by a numerical example.

The method is of considerable importance in a number of practical applications, such as the operation of relays; in the pulling into step of synchronous motors; in the short-circuiting of and quick-response excitation of large alternators; in production schedules depending upon changes in speed of large industrial motors; in the proper performance of all motors in the field of transportation; and in all magnetic-electric systems where regulation is influenced by the magnetic inertia. This problem is not only electrically, but economically and mechanically, important since the design of such equipment depends upon the relative amount of solid iron which may be used in extreme cases without disturbing the required characteristics of operation.

Transient Oscillations in Distributed Circuits

OSCILLATIONS in transformer and other distributed windings have been subject to analysis both by test and calculation; the mathematical investigation of such oscillations is extended by L. V. Bewley (see footnote). In this paper, the nature of the initial, transient, and final distributions of potential are mathematically analyzed and discussed, showing the effects of the following:

1. Losses
2. Circuit constants
3. Neutral impedances
4. Applied wave shape
5. Available methods for controlling distribution

The losses in a transformer circuit during a high frequency transient are due to series resistance in the winding (including skin effect) and dielectric losses and leakage currents from the winding to ground and between points at different potentials on the winding. These losses have a four-fold effect on the character of the oscillations: (1) the amplitudes of the harmonic oscillations are decreased; (2) the frequencies of the harmonic oscillations are slowed down; (3) decrement factors are introduced; and (4) the final distribution is not linear. It is theoretically possible to choose such losses that all oscillations vanish.

In analyzing the effects of circuit constants, most distributed circuits may be classified under four ideal combinations: (1) self-inductance and ground capacitance (the transmission line); (2) self-inductance, series capacitance, and ground capacitance; (3) self- and mutual inductance, and ground capacitance; and (4) self-inductance and mutual inductance, series capacitance and ground capacitance (the transformer). The effects of these different combinations of circuit constants are described by equations and graphs in the complete paper. It is shown that they may be discussed from three different points of view: (1) fixed distribution plus harmonic standing waves; (2) fixed distribution plus harmonic traveling waves; and (3) simple traveling wave plus distortion terms. Complete sets of curves for the initial and final distributions are given.

A rigorous mathematical treatment for any generalized neutral impedance is not attempted, but two approximate methods of analysis are given. In the first method, the neutral voltage is determined by solving the approximate external equivalent circuit of a transformer, and, using this voltage as an applied wave; the corresponding distribution then is found and added to the distribution due to the wave at the line terminal and with the neutral grounded. This method is illustrated for a capacitance in the neutral. In the second method, the circuit consisting of self-inductance, ground capacitance, and series capacitance is used to represent the transformer, and the solution for the neutral voltage obtained by means of the Heaviside operational calculus. This latter method gives fairly good results for the neutral voltage, but only a rough approximation for the internal distribution.

The solutions are given for the following representative applied wave shapes, and the general method of analysis is specified: (1) infinite rectangular wave; (2) finite rectangular wave; (3) uniformly rising front; (4) typical lightning wave; (5) damped oscillation; and (6) sustained oscillation. The solution for each of these cases is illustrated either by graphs or cathode ray oscillograms, or both.

The control of the transient distribution is discussed with respect to: (1) maintenance of constant neutral

Abstracted from "Transient Oscillations in Distributed Circuits, with Special Reference to Transformer Windings" (**No. 31-96**) by L. V. Bewley, presented at the A.I.E.E. summer convention, Asheville, N. C., June 22-26, 1931.

conditions, and (2) control of the oscillations by shunt or series capacitances or combinations of both, by ground capacitance, and by losses. It is shown that while the addition of ground capacitance increases the amplitudes of the space harmonics, it slows the natural frequency of oscillation, and therefore may prevent the occurrence of abnormal voltage to ground before the applied terminal wave has disappeared. However, it increases the gradients along the winding, and therefore does not offer the ideal solution that their elimination provides. Stress is placed on the control of oscillations by the use of losses, particularly by shunt resistance with an exaggerated negative characteristic; and the possibility of a combined lightning arrester and tied-in shunt resistor for controlling the distribution is pointed out. There also is included in the paper a short historical sketch on this phase of transformer investigations, and a short bibliography.

Non-Linear Circuits for Relay Applications

Study and analysis of non-linear circuits reveal characteristics which mark them as capable of being adapted to a variety of special uses. A simple series circuit of this type is especially well adapted for relay applications, and obviates some of the undesirable features of mechanical relays.

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NO PRACTICAL problems lend themselves to solution by available mathematical tools as readily as do linear electrical circuits. In non-linear circuits, however, wherein the magnitude of the different elements of inductance, capacitance, or resistance, become functions of the current or other variables, the analytical problem is complicated greatly. Mathematical impedimenta need not intimidate the experimental approach, however, for many of the non-linear circuits may be studied in this manner with the simplicity characteristic of the more familiar circuits. In this connection it is probable that a lack of that potent aid to research—analysis—accounts in some degree for the present elementary state of development of this type of circuit.

Many so-called linear circuits containing ferromagnetic core material possess linear characteristics over their normal operating ranges, but do not even approximate linear operation during abnormal conditions. For this reason these supposedly linear circuits sometimes behave in a manner regarded as anomalous, when in reality such behavior is related directly to the fundamental *non-linear* nature of the circuits. Thus various types of instability in power circuits incorporating capacitance probably can be analyzed in terms of elementary non-linear circuits. A careful study and analysis of various circuits will reveal many applications not readily apparent. One application of this character consists in the use of a simple series non-linear circuit in conjunction with apparatus already available for a non-mechanical relay having practically ideal characteristics.

The voltage-current characteristic for a series non-linear circuit consisting of resistance, capacitance, and an iron-core inductance, may be seen in Fig. 1. The similarity between this characteristic and the characteristic for an ideal relay is evident at a glance. As may be seen from the curve, this circuit is "voltage sensitive," that is, at the critical voltage a large current rise may be observed in response to a small change in voltage. Thus at or near this critical point, a change in voltage of only 0.01 per cent may result in a 100 per cent increase in current.

An oscillographic study of the circuit of Fig. 1 reveals that the low-current region A is associated with the magnetically unsaturated region, or more properly the hysteresis region of the iron-core reactor, while in region C the current has risen to such values that saturation has taken place. Region B, or the critical part of the voltage-current curve, corresponds to that portion of the magnetization characteristic of the core material loosely referred to as the "knee," and in this region the instantaneous current rise is such that the instantaneous capacitance and inductance voltages are equal and opposite during some portions of the voltage

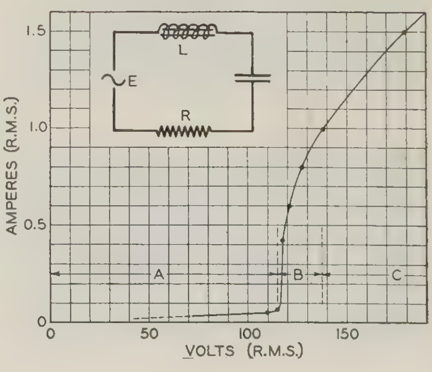


Fig. 1. Voltage-current characteristic for a series circuit containing as its non-linear element an iron-core reactor

Based upon "Studies in Non-Linear Circuits" (**No. 31-37**) presented at the A.I.E.E. winter convention, New York, Jan. 26-30, 1931.

cycle. In this limited region of resonance the peak value of current is limited only by resistance, and thus may be calculated from the d-c. resistance of the circuit and the corresponding instantaneous value of applied voltage. This condition is illustrated by the oscillogram shown in Fig. 2. Here the cyclic period of resonance occurs during the interval indicated by arrows, and during this period also the current is at its peak value. This quasi-resonant state has been called non-linear resonance to distinguish it from linear resonance from which it differs in important respects. Non-linear resonance is analogous to linear resonance in that the current is resistance-limited, and that the sum of the reactance voltages is zero; it differs from ordinary resonance phenomena, however, in that the period during which the resonance condition

$$-l\frac{l}{C}\int i\,dt = L\frac{di}{dt} = K\frac{d\Phi}{di}\,\frac{di}{dt}$$

is satisfied, occupies but a small portion of each steady-state cycle.

Application to A-C. Relays

A relay must possess in general two characteristic properties: (1) a non-linear actuating characteristic, and (2) capability of power amplification, which means that the ratio of controlled to consumed power must be high. The voltage-current characteristics of a series non-linear circuit make it admirably well adapted to fulfilling the first mentioned requirement. The second requirement may be obtained by combining this circuit with the saturable core reactor as shown in Fig. 3. The saturable core reactor (A.I.E.E. JOURNAL, Oct. 1924, p. 958-66) is essentially a special type of reactor having a-c. load windings and d-c. control windings so arranged that no power is transferred between the load and control circuits. In the arrangement shown in Fig. 3 the voltage across the capacitance in the resonant circuit is used to actuate the saturating reactor which in turn controls a load through its a-c. circuit.

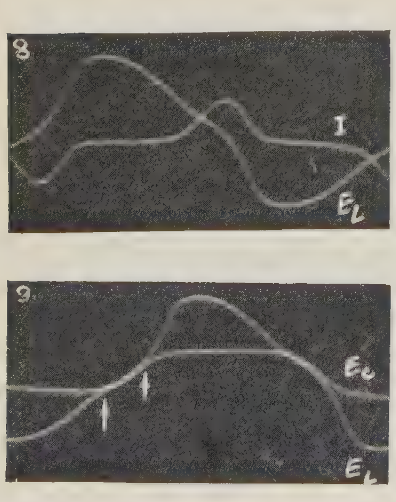


Fig. 2. Typical oscillograms showing voltage and current relations for range "B" of Fig. 1. Arrows denote range of non-linear resonance

I —current
E_L—inductance voltage
E_C—condenser voltage

Voltage-current characteristics for different parts of this relay arrangement also are shown in Fig. 3. Overall operating characteristics of the device are indicated in the curve I_3, which is a close approximation to the characteristics of an ideal relay. Curves are shown for two values of load resistance (R_2). From these two curves it is quite obvious that the ratio of "on" to "off" load current may be made as large as desired, it being a function of the design of the saturating reactor, and governed by the same considerations as in all circuits where this device is used.

Of some importance in this application is the amount of power which may be controlled in a relay of this type. For a saturable core reactor the power amplification factor is a function of the maximum and minimum values of impedance required, which are related in turn to the "on" and "off" load current. Theoretically, the power amplification of a reactor of this type is quite unlimited but practically a factor of 1,000 for an incandescent lamp load has not been exceeded to date. This present limit can be exceeded quite readily, however, by cascading the saturable reactors. Since there is no limit to

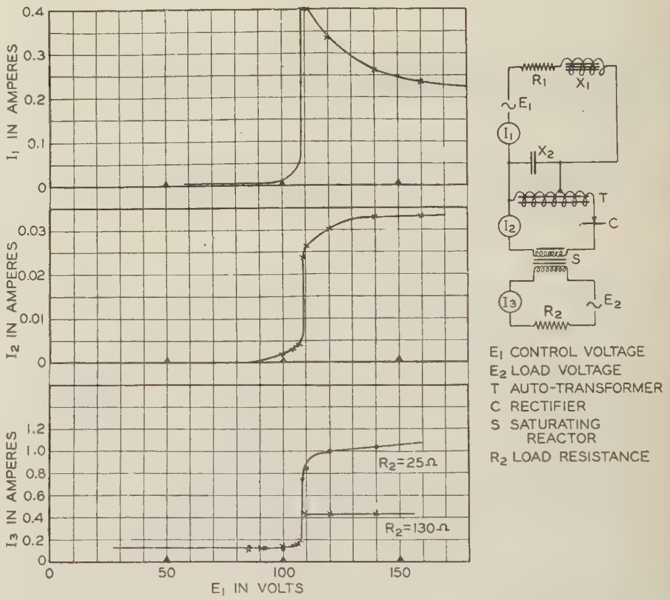
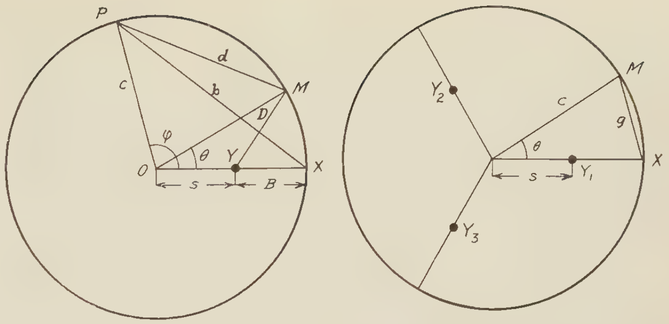


Fig. 3. A-c. relay made up of a series non-linear circuit and a saturable-core reactor with voltage-current curves for different circuit branches

the number of reactors which may be cascaded, accordingly there is no limit to the power amplification that may be obtained. It may be interesting to note that in an experimental set-up a power amplification of 10,000 is obtainable in only two stages, and with comparatively inefficient equipment.

The sensitivity of resonant relays is limited by the characteristics of the resonant circuit and of the saturable reactor circuit. The most sensitive relay action is obtained when only a small amount of power is taken from the resonant circuit and in practical relays a 1 per cent change in voltage has been found

sufficient to determine the "on" or "off" condition. Constancy of the control circuit frequency is another factor influencing to a certain extent the relay sensitivity. With a supply frequency of 60 cycles, however, variations in relay operating voltage are only about 1 per cent per cycle change in frequency. Means are available for obtaining still greater sensitivity, but up to the present time no application has required it.



Figs. 1 and 2. Thin tube with enclosed filament (left) and three-phase cable with sheath (right)

Proximity Effect in Cable Sheaths

Formulas supplementing those previously published and making it possible to calculate the losses in cable sheaths simply and accurately are presented herewith. These cover a wide range of cases.

By
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LEAD SHEATHS of underground cables, being conductors two or three inches in width, usually will have noticeable circulating currents flowing in them due to the proximity of electric power currents. The calculation of the circulating currents and their losses is called a proximity effect calculation, and the result takes the form of a power series.

The problems encountered deal with current density, energy loss, and voltage drop. Certain of these are discussed in "Losses in Grounded Sheaths of Single-Conductor Cables," by H. B. Dwight, *Electric Journal*, Feb. 1924, p. 62. Methods are now available for applying these calculations to a wider number of cases and with increased accuracy.

Considering a very thin tube enclosing a filament as in Fig. 1, the current in the sheath is

$$i_{(\theta)} = -\frac{I}{\pi c t} \sum_{n=1}^{\infty} \frac{s^n}{c^n} \frac{l^4 + j\, l^2 n}{l^4 + n^2} \cos n\,\theta \qquad (1)$$

where

I = current in filament at Y

c = mean radius of tube in cm.

t = thickness of tube in cm.

s = distance in cm. from center of sheath to centers of the copper conductors

$$l^2 = \frac{\omega\, 2\,\pi\, c\, t}{\rho_s}$$

$\omega = 2\,\pi f$

f = frequency in cycles per sec.

ρ_s = resistivity of the tube in abohms per cm. cube

If there are currents in more than one location within the sheath, each produces its own sheath current independent of the others, and the total sheath current is obtained by addition. The result of distributed currents is given by integration.

Energy Loss Calculations

The loss in the sheath of a three-phase cable is of importance with cables of large size. Referring to Fig. 2 the loss in the open-circuited sheath is given by the following expression, which was published by F. W. Carter, as eq. 19 in the *Proc. of the Cambridge Phil. Soc.*, V. XXIII, 1927, p. 905.

$$\frac{\text{Loss in lead sheath}}{\text{Loss in three copper conductors at 0 freq.}} = \frac{2\,a^2}{c\,t}\,\frac{\rho_s}{\rho_c} \sum_{n=1}^{\infty} \frac{s^{2n}}{c^{2n}} \left(\frac{l^4}{l^4+n^2}\right) \sin^2\left(\frac{n\,\pi}{3}\right) \qquad (2)$$

where

a = radius in cm. of a solid copper wire of the same resistance as the stranded copper conductor

ρ_c = resistivity of copper

Calculations based on these formulas for three-conductor three-phase cables with open-circuited sheaths indicate that the sheath loss with a typical cable of 500,000 cir. mils per conductor is 5 per cent of the loss in the three copper conductors at 0 freq., and in a typical large cable of 1,000,000 cir. mils per conductor the sheath loss is 15 per cent of that in the three conductors.

The loss in short-circuited non-magnetic sheaths in a

From "Proximity Effect in Cable Sheaths" (No. 31-72) presented at the A.I.E.E. North Eastern District meeting, Rochester, N. Y., April 29-May 2, 1931.

single-phase circuit is given by eq. 28 of the *Electric Journal* article previously referred to. However, this equation can be improved by making it more rapidly convergent for wide spacings between the cables. This is done by a slight change in the calculation, making the initial terms the same as in the usual impedance formula.

Using the notation of the present article let

$$P = \frac{-j\,\omega\,\text{logn}\,\dfrac{s}{c}}{j\,\omega\,2\,\text{logn}\,\dfrac{s}{c} + \dfrac{\rho_s}{2\pi c t}} \qquad (3)$$

$$F_n = j\,l^2\,(1 + 2P)\,\frac{c^n}{n\,s^n} \qquad (4)$$

$$B = j\,l^2\left[-2A\,\text{logn}\,\frac{s}{c} + \sum_{k=1}^{\infty}\frac{c^k}{k\,s^k}F_k\right] \qquad (5)$$

$$G_n = j\,l^2\left[2A\,\frac{c^n}{n\,s^n} - \frac{F_n}{n} + \frac{c^n}{n\,s^n}\sum_{k=1}^{\infty}\frac{(n+k-1)\,!}{(n-1)\,!\,k\,!}\,\frac{c^k}{s^k}F_k\right] \qquad (6)$$

n and k denote integers.

In the equations for B and G_n, $A = 0$. For C and H_n use the formulas for B and G_n respectively, except change A to B and F to G. Similarly for D and I_n, change A to C and F to H, and so on.

$$L = P + B + C + \ldots \qquad (7)$$

$$M_n = F_n + G_n + H_n + \ldots \qquad (8)$$

$$\frac{\text{Loss in sheath}}{\text{Loss in conductor at zero frequency}} = \frac{a^2}{c\,t}\,\frac{\rho_s}{\rho_c}\left[2\,|\,L\,|^2 + \sum_{n=1}^{\infty}|\,M_n\,|^2\right] \qquad (9)$$

$|\,L\,|^2$ is the square of the absolute value of L.

An approximate formula for this loss ratio is

$$\frac{2\,a^2}{c\,t}\,\frac{\rho_s}{\rho_c}\,|\,P\,|^2 \qquad (10)$$

A typical example calculated for a 60-cycle, single-phase circuit with 2,000,000 cir. mil single-conductor cables indicated a sheath loss of 49 per cent of the loss in the conductor at 0 frequency, based on eq. 9, while the approximate formula eq. 10 indicated a loss of 41 per cent. This latter value is the same as would have been obtained using the well-known approximate formula

$$\text{Effective resistance} = R_c + \frac{R_s\,X_m^2}{R_s^2 + X_m^2} \qquad (11)$$

When three single-conductor cables with short-circuited lead sheaths lie in a plane and carry balanced three-phase current, the losses in the two outer sheaths are not the same. The difference is great enough to justify adding a formula for the loss in the second outside sheath in addition to eq. 32 and eq. 34 of the previously mentioned *Electric Journal* article. Using the notation of that article, let

$$P_o = A_{co} + B_{co} + C_{co} + \ldots$$

$$P_n = A_{dn} + B_{dn} + C_{dn} + \ldots \qquad n \neq 0$$

$$\frac{\text{Loss in sheath of second outside cable}}{\text{Loss in conductor at zero frequency}} = \frac{a^2}{c\,t}\left[2\,|P_o|^2 + |P_1|^2 + |P_2|^2 + \ldots + |P_n|^2 + \ldots\right] \qquad (12)$$

Various problems in proximity effect and shielding in wires and thin tubes can be solved by these methods. Sheath losses are of sufficient importance to warrant being considered in all cases, even though frequently it will be desired only to compute the losses to show that they are practically negligible. In other cases, however, the effects are of engineering importance, and the design of conductors will depend upon the values computed.

Harmonic Generation by Grid Circuit Distortion

THE USUAL vacuum tube harmonic generators are fundamentally high distortion amplifiers operated under conditions of grid bias and plate voltage which, to distort the input voltage wave, utilize the non-linear relation between plate voltage and plate current. A paper published in the June 1931 issue of the A.I.E.E. TRANSACTIONS (see footnote) gives the result of an investigation into the possibilities of using the non-linear grid voltage-current characteristic to produce harmonics. Grid distortion can be utilized by operating the tube so that the grid goes positive for a part of each fundamental frequency cycle and then inserting in series with the grid lead an impedance across which the grid current impulses produce a voltage drop rich in harmonics, which then is amplified in the plate circuit.

The grid circuit distortion harmonic generator has the advantages of producing the harmonic in one circuit and developing the power in another, combined

Abstracted from "Harmonic Generation by Means of Grid Circuit Distortion" (**No. 30-144**) by F. E. Terman, (Asst. Prof. Elec. Engg., Stanford University, Calif.) D. E. Chambers General Electric Co., Schenectady, N. Y.) and E. H. Fisher (Research Assistant, Stanford University, Calif.). Originally presented at the A.I.E E. Pacific Coast convention at Portland, Ore., Sept. 2-5, 1930 (Eighth District 1930 prize paper). Published in A.I.E.E. TRANSACTIONS, V. 50, No. 2, June 1931, p. 811-17.

with the very high distortion properties of the grid circuit. The result is that the grid distortion harmonic generator develops from 100 to more than 1,000 times as much power on the higher harmonics as does the usual plate distortion generator. Thus, when using a suitable parallel resonant circuit as the distorting grid impedance, a steady output of 135 volts effective has been obtained from a radio receiving tube on the 22nd harmonic. When the grid impedance consists of a large inductance it is possible to generate simultaneously at least 1/20th milliwatt of power on every harmonic up to the 50th. The grid circuit input power required to give these results is several hundred milliwatts in the case of the parallel resonant circuit, and considerably less when a grid inductance is used.

The paper gives the mechanism of operation, illustrated with oscillograms and harmonic spectra, and includes a discussion of the effect of circuit conditions on the operation of the grid distortion generator.

Discussion offered incident to the original presentation of this paper pointed out that:

"In view of the fact that all of the results discussed in the paper are for a low fundamental frequency, it may be of interest to mention some work done . . . . at frequencies above 3,000,000 cycles, using tubes having ratings up to 250 watts . . . . The grid distortion harmonic generator using tuned grid impedance is characterized by a harmonic output that decreases very slowly as the order of the harmonic is increased. The result is that while the grid distortion method of harmonic generation has little, if any, advantage over the usual arrangement on the second and third harmonic, it is much superior on higher harmonics . . . . operative at fundamental frequencies above 3,000 kc., although adjustments were . . . . critical with unneutralized circuits. . . . a reasonable amount of power (has been obtained) on 8 meters with a generator drive by an 80-meter crystal."

The Trend in Dielectric Research

A résumé of some of the important advances made during the past year in the fields of physics and chemistry as applied to the fundamental theory underlying successful electrical insulation.

By
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THE PAST YEAR has been exceptionally rich in the results of dielectric research. Rather than attempt a review of all the new work which has come to my attention, I prefer to point out what seems to me to be an outstanding feature of the year's work, namely, an unusual intensity of the study of insulating liquids and some of the outstanding results thereof.

Several investigations are under way on the electrical properties of pure hydrocarbon liquids. From one of these there is some indication of a correlation between conductivity, as measured with continuous potential, and well recognized molecular properties. For the most part, however, the outstanding results of experiments of this character are to show that it is always possible, by further distillation and purification, to lower the conductivity still further. Values of conductivity of 10^{-18} and 10^{-19} mhos part are reported. These values always pertain to the long-time continuous voltage measurement and the volt-ampere characteristics show a pronounced saturation condition.

From the standpoint of such desirable insulating qualities as high dielectric strength, low dielectric loss, and low rate of deterioration due to whatever cause, these low values of conductivity are no indication of special value. In the matter of dielectric loss, for example, such pure liquids show losses under alternating stress which are far greater than may be accounted for by the final conductivity. The losses are completely accounted for, however, by an initial brief and constant conductivity which may be measured by oscillograph as shown by experiments in my own laboratory at Johns Hopkins University. The nature and type of the ions involved in this initial conductivity as yet are uncertain and present an interesting and important problem. It is of special interest to note that certain highly refined oils in the commercial class may, by similar treatment, have their final conductivity reduced to the same order of magnitude as that pertaining to the chemically pure simple hydrocarbon. In these cases, the ratio of the initial (0.002 to 0.01 sec.) to final (1 min. or more) conductivity may be as great as 500:1.

Essentially full text of the annual report of Doctor Whitehead as chairman of the committee on electrical insulation, division of engineering and industrial research, National Research Council, as presented at the fourth annual meeting and conference of that committee held at Harvard University, Cambridge, Mass., November 13 and 14, 1931.

The value of this ratio for the commoner, but good, insulating oils is from 4:1 to 10:1. The great differences in these ratios is caused by the differences in values of the final conductivities. The initial conductivity of the highly purified liquids approaches in value that of the commoner oils. In all cases a dielectric loss in the oil alone is accounted for completely by the initial conductivity.

Colloid Theory of Dielectric Behavior

There is increasing evidence that the electric ions involved in the dielectric loss in oils are larger than molecules. Attention already has been called to the possibility of this by Prof. J. W. Williams of the University of Wisconsin. In a series of papers stretching over the last few years, Professor Böning of Tung-Chi University has developed a theory of dielectric behavior based upon the properties of colloids, which he has applied experimentally and qualitatively, at least, to all the important phenomena appearing in the application of dielectrics as insulators. Briefly, the theory is as follows: All liquid insulators such as oil contain traces of colloidal particles the surfaces of which attract electric ions of one sign and hold them tight through the phenomenon of adsorption. The charges may be positive or negative according to the material, and the charged colloidal particles attract to themselves liquid ions of the opposite sign, of which there always are some present. The aggregate, therefore, consists of a double layer of opposite charges of which, however, the outer layer is very much more loosely bound than the inner. Under a sufficiently strong electric field the outer layer is detached and passes relatively rapidly to one electrode. The charged colloid particles thus left, owing to their size and mass, move slowly towards the opposite electrode. In the neighborhood of that electrode these particles may accumulate, forming a space charge, and thus reducing the field in the middle region and raising it near the electrode.

Experimental evidence of the presence of these space charges was presented several years ago by Whitehead and Marvin, and other similar evidence has been presented more recently by Schaefer. Böning recently has shown experimentally the presence of an increase of hydrostatic pressure under one electrode due to the accumulation of space charges. He invokes this phenomenon as an explanation of a condition sometimes observed in high voltage cables in which the compound appears to have migrated away from the central conductor. The space charges have low mobility and are evident only in studies with continuous voltage. The space charges as such do not accumulate at ordinary alternating frequencies, say 60 cycles, and the losses in oils at these frequencies are due to the oscillatory or perhaps rotatory motion of the particles or aggregates. They may be removed temporarily by the long application of a continuous field with consequent temporary reduction of loss.

Colloids vs. Dielectric Strength

The influence of the presence of colloids upon the dielectric strength of oils also is being studied. According to Böning, as the amount of colloid material in purified insulating oils of several types increases up to 0.02 per cent there is a sharp reduction of dielectric strength to about 80 per cent of that of the pure oil. Greater proportions of colloid material, however, seem to have no increased effect. The breakdown strength under continuous voltage is 60 per cent of that under alternating stress. These results are said to be in general accord with the theory of space charges arising in the adsorption of ions of one sign and the resulting space charge and high stress near one electrode. Beyond a certain concentration of colloid particles there is no further lowering of dielectric strength because the particles tend to aggregate in large groups with corresponding reduction of the total adsorbing surface.

Further light on the nature of the breakdown of liquids is found in one of the frequent papers by Inge and Walther describing studies of the dielectric strength of xylol when carefully freed of dissolved gases by successive distillation. When so prepared, the breakdown strength of this liquid is independent of the pressure over a wide range, and independent of temperature for continuous and impulse voltages. There is, however, a continuous decrease of the breakdown alternating voltage with increasing temperature. The conclusion is reached that the breakdown in liquids is associated with the boiling point. Gas lowers the boiling point and facilitates breakdown. It would appear that the lowering of breakdown under alternating stress is due to increased local temperature caused by the back-and-forth motion of the colloid particles previously referred to, thus leading to breakdown, somewhat in accordance with the proposal of Gunther-Schultz. As related to this question of the picture of the nature of breakdown, there also may be mentioned the interesting report by Gemant of the photographic record of tiny local discharges within the oil before final failure.

Low Frequency Losses

Several papers have appeared discussing the possibility that dielectric losses at low frequencies may be occasioned by polar-molecular orientation in the Debye sense, as suggested by Kitchin and Mueller two years ago. Of these may be mentioned especially the work of Kirch and Riebel, who have reported several studies on oil-resin mixtures in various properties over a range of frequency from 50 to 10,000 cycles and in the temperature range from −30 to −160 deg. cent. These authors present a qualitative analysis of their results strongly supporting their proposal that the changes in power factor and dielectric constant with temperature and frequency are due to dipole orientation.

Ornstein and Willemse have presented other evidence in favor of molecular orientation as a cause of

dielectric loss. They measure the Kerr effect, the dielectric loss, the temperature coefficient of dielectric constant, and the viscosity of a basic petroleum oil and eighteen different samples or cuts from the same oil by the separation of different compounds and their successive purification. Their results are presented in a series of diagrams in which the samples are arranged in horizontal rows, the several rows representing different groups of definite chemical character and the samples in each row being of different degrees of refinement. Correlation now is looked for in the changes in those electric properties dependent upon polar orientation as between the various groups and the respective samples in each group. Close correlation is found between changes in the value of the Kerr constant, the temperature change of dielectric constant, and in the values of dielectric loss, as well as in other properties. The whole presents a very convincing picture.

However, sharp exception to these proposals has been taken by A. Gemant in several papers, as well as in his interesting text, "Electrophysik der Isolierstoffe." In particular, he recently has reported a series of studies, similar to those of Kirch and Riebel, in which he shows that the oil carefully freed of colloids shows also the power factor variation attributed to polar molecules and that the increases due to the addition of colloid material by no means are proportionate to the amounts added. Further, he shows that similar changes may be brought about by the addition of non-polar impurities. He presents an equally convincing picture that the effect in question may be accounted for by the conductivity due to impurities and the consequent variations in structure, and that the variations of loss and power factor in the low temperature range for oils are in accordance with the Maxwell theory of absorption as extended by Wagner. He reaches the conclusion that losses due to polar molecules can occur only in frequencies at 10^4.

If time permitted, I should like to review briefly the important contributions from Rogowski, Joffé, Inge and Walther, and von Hippel, on the conductivity and electric breakdown in crystals. These contributions constitute notable extensions of present knowledge of the mechanism of molecular failure under electric stress. Reference to these and to all other papers mentioned will be found in the list which accompanies this report. These indicate that, as stated previously, the past year has been exceptionally rich in the results of dielectric research; it is extremely interesting to note also that the studies of engineers engaged in the direct application of dielectrics as insulators are approaching and supporting each other to a far greater extent than ever before.

Monograph Publication

One of the most important accomplishments of the year has been the appearance of the first of a series of monographs on dielectrics and insulation, which are to be published under the auspices of the N.R.C. committee on electrical insulation. The title of this first volume is "The Nature of a Gas," and its author, Prof. L. B. Loeb. The publisher is John Wiley & Sons. This is a remarkably clear and interesting exposition of recent knowledge and theory of the electrical properties of gases. It constitutes a most auspicious opening of a series which should be of great value, and the extension of which will constitute one of the committee's chief future efforts. Other monographs now in preparation are:

Electric Discharge in Gases, K. T. Compton and Irving Langmuir.

Conduction in Gases, J. Slepian and R. G. Mason.

Liquid Dielectrics, Dr. Andreas Gemant.

Solid Dielectrics, C. F. Hill, W. S. & M. Co.

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Space Charge, Colloids, and Properties of Dielectrics

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Importance of Colloid Behavior of Insulating Liquids and Solids, J. W. Williams. Lecture at Washington meeting of N. R. C. committee on electrical insulation, Nov. 1930.

Breakdown

Influence of Colloid Suspensions on Dielectric Strength of Oils, P. Boning. *Zeits. fur Tech. Phys.*, 4, 1931, p. 200. (Up to 0.02 per cent by weight colloid asphalt reduces dielectric strength to about 80 per cent value for pure oil, thereafter no further reduction with more colloids.

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Electric Loss and Electric Dipole Moment in Transformer Oil, Ornstein and Willemse. *Zeits. fur Tech. Phys.*, 9, 1930, p. 345. (Correlation of several factors over frequency range 50 to 10^6 cycles, all pointing to dipole loss.)

Some Electrical Characteristics of Cable Oils, H. H. Race. A.I.E.E. Paper No. 31-47. (Oil test cell; correlation of a-c. and d-c. 1-min. measurements.)

Oil Losses at High Frequencies, Vogler. *Eleck. Nach. Tech.* (Losses in oils at high frequencies 10^6 to 1.3×10^7, calorimeter method; power factor is indication of frequency and losses; no evidence of molecular polarity.)

Tests of Insulating Oils, Weiss and Solomon. *R.G.E.*, 28, July 2, 1930, p. 61. (Extensive study of oxidation and depreciation.)

Dielectric Research, Welo's work with the General Cable Corp.

Conductivity of Insulating Oils II, J. B. Whitehead. A.I.E.E. Trans., V. 50, No. 2, June 1931, p. 695.

Fundamental Properties of Impregnated Paper, J. B. Whitehead and W. B. Kouwenhoven. A.I.E.E. Trans., V. 50, No. 2, 1931, p. 699.

Simultaneous Faults on Three-Phase Systems

FROM published records of flashovers on double-circuit towers which have tripped out both circuits, and from opinions expressed by operating engineers of various power companies, approximately 20 per cent of faults occurring on double-circuit towers involve conductors of both circuits. In addition to these, instances have been reported where faults in substations have involved conductors of circuits not on the same towers. "It seems worth while therefore," states Edith Clarke (A'23) of the General Electric Company, Schenectady, N. Y., in a current A.I.E.E. paper, "to have in convenient form, methods for calculating short-circuit currents, and of determining the stability limit of a system when faults occur simultaneously at two separate and distinct points of the system."

The method of symmetrical components, introduced by C. L. Fortescue (A.I.E.E. Proceedings, Vol. 37, June 1918, p. 629-716) and now being used extensively to determine short-circuit currents and stability limits during transient conditions, have been extended by the author to apply to three-phase systems during simultaneous faults at two or more points. In the positive phase diagram, a general equivalent circuit is developed to replace two simultaneous faults involving any combination of the six conductors. An approximate equivalent circuit to be used with a d-c. calculating table when resistance is neglected also is given. In addition, special equivalent circuits are employed to replace two simultaneous faults and the lines upon which they occur, when these lines are unloaded feeders radiating from a common point or lines of equal impedances bused at both ends.

In the discussion on this paper (A.I.E.E. Transactions, Vol. 50, September 1931, p. 939-41) the author's methods were shown to be of great practical value especially where two or more circuits are strung on the same towers. Some cases of trouble were reported on faulty circuit structures which involved two lines going to entirely different parts of the system. The paper enables protection engineers to work out the complete story of any type of simultaneous fault in quite a reasonable length of time, from which information relay settings may be established. Although developed specially for use with grounded systems, the discussion brought out also the fact that the method may be adapted to the calculation of fault currents and voltages on ungrounded systems which are quite common in Europe.

Abstracted from "Simultaneous Faults on Three-Phase Systems" by Edith Clarke, (No. 31-60) presented at the A.I.E.E. Middle Eastern District meeting, Pittsburgh, Pa., March 11-13, 1931.

News

Of Institute and Related Activities

Winter Convention Presents Elaborate Program

CURRENT engineering improvements in the art, resulting from field, laboratory, and operating experiences will be presented and discussed in the fourteen technical sessions to be held during the A.I.E.E. winter convention, with headquarters in the Engineering Societies Building, 33 West 39th Street, New York, N. Y., January 25-29, 1932. In addition to the excellent technical program there will be interesting inspection trips and numerous entertainment features, with a specially arranged program for the visiting ladies.

Technical Sessions

The technical sessions have been planned so that the interests of any groups may not conflict at parallel sessions and yet subjects of interest to the same groups may be found scheduled close together. Thus those engaged in the fields of power generation, transmission, and distribution will find the sessions on protective devices, distribution circuit lightning protection, selected subjects, and system stability, of particular interest. Those chiefly interested in theory should find the latter session to be of particular interest as well as the sessions on instruments and measurements, general circuit theory, and research. All of the sessions so far mentioned will be held during the first three days of the convention. Designers and electrical manufacturers should find much material of unusual interest in the sessions scheduled for Thursday and Friday; namely two sessions on electrical machinery, one on transportation, and another on electric welding. A session on electrochemistry and electrometallurgy which is of both theoretical and basic practical interest also will be presented on Thursday morning. Friday will be devoted primarily to communication subjects although the papers presented in the symposium on time, and time services, should have a broad general appeal. With a program of such broad scope and timely interest those attending should have little difficulty in finding sessions of unusual interest along their particular lines of endeavor.

Entertainment

A buffet supper and smoker with entertainment will be held on Tuesday evening. On the following evening both the Edison Medal and the John Fritz Medal will be presented to the respective medalists. On Thursday evening the annual social event, the dinner dance, will be held. In addition, there will be a number of interesting inspection trips and the special program for the ladies in attendance; more information pertaining to these features will be announced at a later date. Monday and Friday evenings have been left open to afford out-of-town guests an opportunity for theater going, the visiting of friends or making other engagements.

Reduced Railroad Rates

Under the certificate plan reduced railroad rates will be available to members and guests who attend the convention; only half fare need be paid on a return trip over the same route, provided a total of at least 100 certificates are deposited at the registration desk. Rates apply to all who attend the convention and to dependent members of their families. Each member or guest should obtain a certificate when purchasing his one-way ticket to New York, explaining to the ticket agent that he wishes the certificate authorized by the passenger associations for the winter convention of the American Institute of Electrical Engineers.

On arriving at the convention the certificate should be deposited at the registration desk. There it will be held for validation by a railroad representative and if 100 or more certificates are validated, these certificates will be returned to the owners. By presenting the validated certificate when purchasing a return ticket, only half fare will be charged. Local ticket agents should be consulted regarding conditions affecting this plan, as it applies only within certain dates, depending upon the territory. *Everyone* whose one-way fare is more than 66 cents *should get a certificate* whether or not he intends to use it. *By neglecting to do so others may be deprived of considerable saving.*

Committees

The 1932 winter convention committee is constituted as follows: E. B. Meyer, *chairman*; O. H. Caldwell, H. P. Charlesworth, Harold C. Dean, W. H. Harrison, C. R. Jones, G. L. Knight, C. E. Stephens and R. H. Tapscott.

Chairmen of the subcommittees are: C. E. Stephens, convention executive committee, with C. R. Jones as vice-chairman; G. W. E. Draper, smoker; E. J. Johnson, dinner dance; W. R. Smith, inspection trips; and Mrs. E. B. Meyer, ladies' entertainment.

Schedule of Events

Monday morning and evening have been left open for committee meetings. Capital letters A, B, etc., denote technical sessions.

Monday, January 25

10:00 a. m. Registration
2:00 p. m. Opening of Convention
A—Protective Devices
B—Instruments and Measurements

Tuesday, January 26

10:00 a. m. C—Symposium on Distribution Circuit Lightning Protection
D—General Circuit Theory
2:00 p. m. E—Research
F—Selected Subjects
6:00 p. m. Buffet Supper and Smoker

Wednesday, January 27

10:00 a. m. G—Symposium on System Stability
1:15 p. m. Inspection Trips
2:00 p. m. Board of Directors Meeting
8:30 p. m. Edisón Medal and John Fritz Medal Presentations

Thursday, January 28

10:00 a. m. H—Electrical Machinery
I—Electrochemistry and Electrometallurgy
2:00 p. m. J—Electrical Machinery
K—Transportation
7:30 p. m. Dinner Dance

Friday, January 29

10:00 a. m. L—Symposium on Time and Time Services
2:00 p. m. M—Communication
N—Electric Welding

Tentative Technical Program

Monday—2:00 p. m.

A—Protective Devices

A New High Speed Distance Relay with Composite Impedance—Reactance Characteristic, S. L. Goldsborough and W. A. Lewis, Westinghouse Elec. & Mfg. Co.

The Theory of Oil Blast Circuit Breakers, D. C. Prince, General Electric Co.

*The Practical Application of the Oil Blast Principle of Circuit Interruption, R. M. Spurck, General Electric Co.

*Recent Developments in Arc Rupturing Devices, R. C. Van Sickle and W. M. Leeds, Westinghouse Elec. & Mfg. Co.

Extinction of A-C. Arcs in Turbulent Gases, T. E. Browne, Jr., Westinghouse Elec. & Mfg. Co.

B—Instruments and Measurements

High Voltage Bridge for Measurements of Cable with Grounded Sheaths, C. L. Dawes and A. F. Daniel, Harvard University

A High Sensitivity Power Factor Bridge, W. B. Kouwenhoven and Alfredo Banos, Jr., The Johns Hopkins University

*Capacitance and Power Factor Measurement by the Capacitance Bridge, R. P. Siskind, Harvard University

*Aging and Elastic Hysteresis Instrument Springs, R. W. Carson and P. MacGahan, Westinghouse Elec. & Mfg. Co.

*An Automatic Oscillograph, C. M. Hathaway and R. C. Buell, General Electric Co.

*The Photoelectric Recorder, C. W. LaPierre, General Electric Co.

Tuesday—10:00 a. m.

C—Symposium on Distribution Circuit Lightning Protection

*Lightning Protection of Transformer Secondaries, C. Francis Harding and C. S. Sprague, Purdue University

*Field Studies of the Protection of Distribution Transformers by Lightning Arresters, Including the Effect of Interconnection, K. B. McEachron, General Electric Co.

*The Protection of Distribution Transformers from Failures Due to Lightning, A. M. Opsahl, Westinghouse Elec. & Mfg. Co., A. S. Brookes and R. N. Southgate, Public Service Electric and Gas Co.

*Studies in Lightning Protection on 4,000-Volt Circuits—III, D. W. Roper, Commonwealth Edison Co.

*Investigation of Lightning Protection for Distribution Transformers, T. H. Haines and C. A. Corney, The Edison Electric Illuminating Company of Boston

*Distribution System Lightning Studies by Philadelphia Electric Company, H. A. Dambly, H. N. Ekvall, and H. S. Phelps, Philadelphia Electric Co.

D—General Circuit Theory

Equivalent Circuits, F. M. Starr, General Electric Co.

Transient Oscillations of Mutually Coupled Windings, L. V. Bewley, General Electric Co.

The Geometrical Circuits of Electrical Networks, R. M. Foster, American Tel. & Tel. Co.

Tuesday—2:00 p. m.

E—Research

Some Fundamental Theory and Experiments on Electrical Precipitation, A. W. Simon and L. C. Kron, Tennessee Coal, Iron and Railroad Co.

Radio Interference from Corona on High Voltage Insulators, F. O. McMillan, Oregon State Agricultural College

*Predetermination of the A-C. Properties of Dielectrics from the Continuous Potential Characteristics, J. B. Whitehead and A. Banos, Jr., Johns Hopkins University

The Breakdown of Glass with Alternating Potentials, N. D. Kenney, A. M. Luery and J. D. Moriaty, Standard Cable Corp.

Relationships among the Magnetic Properties of Magnet Steels and Permanent Magnets, K. L. Scott, Western Electric Co.

F—Selected Subjects

*Introductory Statement—Steam *vs.* Electrically Driven Auxiliaries for Steam Power Stations, F. H. Hollister, Sargent and Lundy, Inc.

Steam Driven Auxiliaries for Power Plants, W. Poole Dryer, Stone and Webster, Inc.

Electrically Driven Auxiliaries for Steam Power Stations, L. W. Smith, Sargent and Lundy, Inc.

*An Improved Type of Limiting Gap for Protecting Station Apparatus, A. O. Austin, Ohio Insulator Co.

Wednesday—10:00 a. m.

G—Symposium on Stability

*Proposed Definitions of Terms Used in Power Stability Studies—Report of Subject Committee on Definitions, H. K. Sels, Chairman

*Recommended Current Decrement Curves—I, W. C. Hahn, General Electric Co., and C. F. Wagner, Westinghouse Elec. & Mfg. Co.

*Recommended Decrement Curves—II, W. C. Hahn, General Electric Co.

*Recommended Decrement Curves—III, C. F. Wagner and S. H. Wright, Westinghouse Elec. & Mfg. Co.

*Operating Experience of the Philadelphia Electric Company System from the Stability Point of View, R. A. Hentz and J. W. Jones, Philadelphia Electric Co.

Thursday—10:00 a. m.

H—Electrical Machinery

*An Induction Motor With Paralleled Rotor and Stator, A. G. Conrad and R. G. Warner, Yale University

*Some Considerations in the Design of Damper Windings for Synchronous Motors, C. C. Shutt, Westinghouse Elec. & Mfg. Co.

*Surge-Proof Transformers, H. V. Putman, Westinghouse Elec. & Mfg. Co.

*Effect of Transient Voltages on Power Transformer Design IV—Transformation of Lightning Waves to Secondary Windings, K. K. Palueff and J. H. Hagenguth, General Electric Co.

I—Electrochemistry and Electrometallurgy

Power Losses in Electrolytic Condensers, F. W. Godsey, Jr., The Safety Car Heating and Lighting Co.

Film Characteristics of Electrolytic Condensers, F. W. Godsey, Jr., The Safety Car Heating and Lighting Co.

*The Effect of Polar Molecules in Dielectrics, W. N. Stoops, Westinghouse Elec. & Mfg. Co.

*Cobalt Magnet Steel, P. H. Brace, Westinghouse Elec. & Mfg. Co.

Thursday—2:00 p. m.

J—Electrical Machinery

*Commutation Considered as a Switching Phenomenon, R. E. Hellmund and L. R. Ludwig, Westinghouse Elec. & Mfg. Co.

Equalizing Currents in the Armature of a D-C. Machine, R. M. Baker, Westinghouse Elec. & Mfg. Co.

Calculation of the No-Load Damper Winding Loss in Synchronous Machines, E. I. Pollard, Westinghouse Elec. & Mfg. Co.

*Mathematical Theory of Sine Wave Generators, L. P. Shildneck, General Electric Co.

K—Transportation

Engineering Features of "Three Power" Locomotives, F. H. Brehob and F. H. Craton, General Electric Co.

Motors for 3,000-Volt D-C. Multiple Unit Cars, J. C. Aydelott, General Electric Co.

The Temperature Rise of Ventilated Railway Motor Armatures, D. A. Lightband, Westinghouse Elec. & Mfg. Co.

*High Capacity Rectifier Efficiency Improved by Sectionalization, A. L. Atherton, Westinghouse Elec. & Mfg. Co.

*European Railway Electrification, W. S. Gordon, Jr., Railway Electrical Engineer, Montclair, N. J., and E. Jaboolian, formerly with Jackson & Moreland, Hoboken, N. J.

Friday—10:00 a. m.

L—Symposium on Time and Time Services

†Astronomical Aspects of Time, E. W. Brown, Yale University

*Modern Developments in High Precision Clocks, A. L. Loomis, Loomis Laboratories, and W. A. Marrison, Bell Telephone Laboratories, Inc.

*The Time Service of the U. S. Naval Observatory, J. F. Hellweg, U. S. Naval Observatory

*Time Services of the Telegraph Companies, G. W. Jansen, Western Union Telegraph Co.

*Time Services of the Power Companies, H. E. Warren, Warren Telechron Co.

Friday—2:00 p. m.

M—Communication

†New Key West-Havana Carrier Telephone Cable, H. A. Affel, American Tel. & Tel. Co., W. S. Gorton and R. W. Chestnut, Bell Telephone Laboratories, Inc.

†The Development of a Hand Set for Telephone Stations, W. C. Jones, Bell Telephone Laboratories, Inc.

†An Automatic Concentration Unit for Printing Telegraph Circuits, G. S. Vernam, International Communications Laboratories, Inc.

†Direct Printing Over Long Non-Loaded Submarine Telegraph Cables, M. H. Woodward, and A. F. Connery, International Communications Laboratories, Inc.

†Carrier Applications to a Telegraph Plant, R. E. Smith and L. A. Kelley, International Communications Laboratories, Inc.

†Direct Solutions of Coupled Tuned Circuits, L. A. Kelley, International Communications Laboratories, Inc.

N—Electric Welding

Forces of Electric Origin in the Iron Arc—An Explanation of Overhead Welding, F. Creedy, R. O. Lerch, P. W. Seal and E. P. Sordon, Lehigh University.

*An Improved A-C. Arc Welder, A. M. Candy, Westinghouse Elec. & Mfg. Co.

*The Fundamentals of the Design of Arc Welding Generators, K. L. Hansen, K. L. Hansen Engineering Co., Inc.

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*These papers are under consideration for presentation at the winter convention, but up to the date of going to press, November 23, they have not been officially placed upon the program.

†These papers will not be published in advance form by the Institute but copies may be made available by the respective authors.

Kansas City District Meeting Well Attended

WITH a total registered attendance of 411 persons the South West District meeting held in Kansas City, Mo., October 22-24, 1931, was particularly noteworthy in the very active participation of Enrolled Students. The final tally of official registration showed 159 Members, 60 men guests, 19 women guests, and 173 students. All six of the District Sections—Dallas, Houston, Kansas City, Oklahoma City, St. Louis, San Antonio—were represented, as were also practically all of the District's fourteen Student Branches.

Although evening and Saturday sessions usually are not crowned with success, the two such sessions held at Kansas City were unquestionably successful if attendance may be taken as an index. Of the four technical sessions the Thursday afternoon and Saturday morning sessions were held in the roof garden ballroom of the Kansas City Athletic Club, while the Thursday evening and Friday morning sessions were held in the beautiful Thomas Alva Edison memorial auditorium in the new office building of the Kansas City Power and Light Company. The evening session in the power company's auditorium was in the nature of a public meeting featuring various angles of the St. Louis-Bagnell interconnection, supplemented by motion pictures of Bagnell Dam and powerhouse, and of the 129-mile "Lake of the Ozarks" created by the dam.

Opening Addresses

With A. E. Bettis, past vice-president (1926-28) as chairman, Dean G. C. Shaad, gave the opening address following the official welcome extended by Col. R. D. Garrett for Kansas City's Mayor, Bryce B. Smith. In his presentation Dean Shaad described the fundamentals of the Institute organization and the reasons underlying the promotion of District meeting activities. He pointed with some pride to the 12.5 per cent growth in Institute membership that has occurred in District 7 for the Institute year recently closed, and commended the District's newer and smaller sections for their active development work.

President C. E. Skinner in addressing the gathering expressed himself as also believing that the "future of engineering students is very bright indeed," pointing out with some emphasis the fact that electrical engineering graduates now are occupied in gainful pursuits in percentages higher than any other class of graduates. Doctor Skinner urged careful stock taking and careful planning for the future during the present period of business unrest, and urged a realization of the cyclic character of the situation. He read a report issued by the United States Secretary of Labor some 47 years ago which specifically made the prediction that (then) "the needs of the world now are more than adequately provided for and it is useless to look to the future for further large developments or profits." Doctor Skinner reviewed very briefly the advancements made in the ensuing 47 years stating that they should be index enough of what can happen during the next period of similar length.

National Secretary F. L. Hutchinson also spoke, emphasizing briefly the need of more constructive attention to the matter of technical advancement and less attention to such current non-productive phrases as "technological unemployment." Mr. Hutchinson pointed out that technical advancement inevitably provides for increases in employment and general productive activities which otherwise never would develop. As one specific example he cited the contributions of Thomas A. Edison, whose work has provided the basis for tremendous industrial activity employing hundreds of thousands of individuals.

Edison Memorial Program

To present a short Thomas A. Edison memorial program Chairman Bettis called upon two Edison Pioneers to speak briefly. Joseph F. Porter (M'87 and Member for Life) president of the Kansas City Power and Light Company, cited the difficulties with which Edison was faced in the early development and promotion of his ideas, calling attention to the value of reverses which necessitate close application to the work in hand. Bringing his reasoning down to date, he urged diligent individual application as an important means of overcoming the present economic disturbance. As a bit of interesting history he mentioned the fact that on November 14, 1881, agreements were signed with Thomas A. Edison giving L. K. Moore and Joseph Chick the right to use in Kansas City patented rights, machines, and associated power plant equipment, resulting in the completion in 1882 of Kansas City's first electric generating plant. William Hahn, Kansas City manager for the General Electric Company, described the basis on which the organization of Edison Pioneers was built and quoted their official aims. Concerning an everlasting memorial to Thomas A. Edison, Mr. Hahn said that "the electric industry is a true and everlasting monument to Edison."

Student Sessions

Two student sessions were held the first day of the meeting at which the following ten papers were presented:

Modulation by Means of a Class B Amplifier, H. D. Labrecht, University of Arkansas.

Michael Faraday—The Man, C. M. Brecheisen, University of Kansas.

Choice of Equipment for Petroleum Pump Stations, V. J. Sittel, Oklahoma A. & M. College.

Accumulation of High Potential Static Charges on Transmission Lines During Sand Storms, C. E. Houston, Texas Technological College.

Sound as Applied to Synchronized Talking Pictures, M. R. James, Missouri School of Mines and Metallurgy.

A Synchronous Contactor in Transient Study, S. P. Robertson, University of Texas.

Control of the Hot-Cathode Thyratron, J. V. Melton, Southern Methodist University.

Design and Construction of Radio Field Intensity Measuring Equipment, G. S. Hammonds, University of Oklahoma.

Carrier Current Communication Over High Voltage Power Lines, J. E. Shepherd, University of Missouri.

Television, W. R. Mitchell, Kansas State College.

Main Sessions

Of the four main sessions, two were devoted to transmission and distribution problems, one to communication, and one, as mentioned, to the St. Louis-Bagnell interconnection. Session chairmen were: D. D. Clarke (M'18) of the Kansas City Section, and District Vice-President G. C. Shaad (F'13) respectively for the two transmission and distribution sessions; Stanley Stokes (F'29) of the St. Louis Section, for the interconnection session; E. T. Mahood (M'28) of the Kansas City Section, for the communication session. All of the eighteen technical papers presented at the four sessions and not previously or contemporarily published in Electrical Engineering in comprehensive form were abstracted on p. 900-3 of Electrical Engineering for November 1931 and hence will not be discussed further here. Papers of both local and general interest were presented. All were well received and actively discussed, although the paucity of written discussion precludes the usual publication of a summarized review of discussion.

Entertainment

Under the influence a very evident air of spontaneous western hospitality, the social functions, staged under the direc-

tion of the local committees, were among the most wholly successful social affairs held this year in connection with major Institute meetings. Local sightseeing trips and inspection trips of a technical nature were available in wide variety; for the women there was a bridge luncheon, several excursions and other enjoyable activities; for those who wanted golf facilities, these were provided also. A dinner dance featuring particularly well planned entertainment and held in the grand ballroom of the Kansas City Athletic Club Friday evening proved a fitting climax for the social activities held in connection with the District meeting. A much appreciated part of the evening's program was the total omission of all speakers.

District 7 Executive Committee Convenes at Kansas City

During the recent District meeting in Kansas City, Mo., a meeting of the executive committee of the Institute's South West District was held on October 23, 1931. Present were: chairman and District vice-president, G. C. Shaad (Lawrence, Kans.); District secretary, R. W. Warner (Lawrence, Kans.); Section chairmen, G. A. Dyer (Dallas, Texas); E. M. Wise (Houston, Texas); George Fiske (Kansas City, Mo.); C. T. Almquist (Norman, Okla.); C. H. Kraft (St. Louis, Mo.); J. E. Woods (San Antonio, Texas); Section secretaries, S. M. Sharp (Dallas, Texas); J. S. Waters (Houston, Texas); R. M. Ryan (Kansas City, Mo.); C. E. Bathe (Oklahoma City, Okla.); C. H. Lankford (St. Louis, Mo.); acting Section secretary, I. A. Uhr (San Antonio, Texas); chairman of District committee on student activities, F. G. Tappan (Norman, Okla.).

In selecting a member to represent this District on the national nominating committee, C. T. Almquist (Norman, Okla.) was declared elected. A motion that Mr. Almquist go uninstructed was carried. G. A. Mills (Dallas, Texas) was nominated as candidate for the office of vice-president from the South West District to be voted upon at the coming spring election of officers. The following four additional members of the coordinating committee were elected: George Fiske (Kansas City, Mo.); S. M. Sharp (Dallas, Texas); C. H. Lankford (St. Louis, Mo.); and E. M. Wise (Houston, Texas). Also to serve on this committee W. L. Upson (St. Louis, Mo.) was elected from the student counselors.

Other matters of interest to the District were discussed, including the date and location of the next District meeting.

In the meeting of student counselors and student Branch chairmen, F. G. Tappen (Norman, Okla.) was elected to succeed W. P. Weinbach (Columbia, Mo.) as chairman of the District committee on student activities.

Directors Meet at Kansas City

A regular meeting of the Institute's board of directors was held at the Kansas City (Mo.) Athletic Club, Friday, October 23, 1931. Present were: *President*—C. E. Skinner, East Pittsburgh, Pa. *Vice-Presidents*—H. P. Charlesworth, New York, N. Y.; W. E. Freeman, Lexington, Ky.; W. B. Kouwenhoven, Baltimore, Md.; T. N. Lacy, Detroit, Mich.; P. H. Patton, Omaha, Neb.; G. C. Shaad, Lawrence, Kans. *Directors*—A. E. Bettis, Kansas City, Mo.; B. D. Hull, Dallas, Tex.; J. E. Kearns, Chicago, Ill.; A. M. MacCutcheon, Cleveland, Ohio. *National Secretary*—F. L. Hutchinson, New York, N. Y.

The minutes of the directors' meeting of August 4, 1931, were approved.

A minute in memory of Thomas A. Edison was adopted. (This minute was published in the November issue of Electrical Engineering, p. 907.)

The board ratified actions taken by the executive committee, under date of September 28, 1931, on 46 applications for admission to the grade of Associate and five to the grade of Member; three for transfer to the grade of Member, and 35 for Student enrolment.

Reports of meetings of the board of examiners held September 23 and October 20, 1931, were presented and approved; upon the recommendation of that board, the following actions were taken on pending applications: 276 Students were enrolled; 59 applicants were elected to the grade of Associate and 12 to the grade of Member; 28 applicants were transferred to the grade of Member and two to the grade of Fellow.

Approval by the finance committee for payment of monthly bills amounting to $36,170.11 was ratified.

Upon the recommendation of the finance committee it was decided, because of present economic conditions, to omit the publication of a year book for 1932, and to suspend until further notice, payment of traveling expenses to provide for the Sections occasional addresses by prominent Institute members designated as "Institute lecturers."

A budget for the appropriation year of the Institute beginning October 1, 1931, submitted by the finance committee, was adopted.

Upon request of the executive committee of the North Eastern District, the board approved the dates May 4-7 for the 1932 District meeting to be held at Providence, R. I.

The following actions were taken upon the recommendation of the standards committee: "Standards for Metal Tank Mercury Arc Rectifiers" prepared by the sectional committee on mercury arc rectifiers, for which the Institute is sole sponsor, approved for submitting to the American Standards Association for approval as a tentative standard; a revision of paragraph 13-250 of A.I.E.E. Standard No. 13, "Transformers, Induction Regulators and Reactors," approved for submitting to the Electrical Standards Committee with the recommendation that it be incorporated in the revision of Standard No. 13 already submitted to that body.

Amendments to the by-laws were adopted canceling the name "Meetings and Papers Committee" wherever they occur in the by-laws and substituting "Technical Program Committee," and canceling the name "Law Committee" and substituting "Committee on Constitution and By-Laws."

Section 71 of the by-laws, relating to the functions of the law committee, was canceled and the following was substituted:

Sec. 71. The committee on constitution and by-laws shall consist of five members and shall consider all matters relating to the constitution and by-laws of the Institute, including the legal status in connection therewith, also all other matters referred to it by the board of directors, the president, or the national secretary. The committee shall make reports and recommendations to the board of directors for action thereon and may consult legal and technical counsel with reference to any question before it.

A new section of the by-laws was adopted, as follows:

Sec.—The committee on legislation affecting the engineering profession shall consist of fifteen members. It shall consider all matters relating to existing or proposed legislation which has an engineering content, and which concerns the welfare of the public or the practise of professional engineering. The committee shall also consider and report upon all other matters referred to it by the board of directors, the president, or the national secretary, and may consult legal counsel with reference to any question before it.

Upon the recommendation of the committee on economic status of the engineer a resolution was adopted urging Institute Sections to cooperate with other local groups of engineers in the organization of an engineers' unemployment relief committee in each community.

In accordance with the constitution and by-laws, the following five members of the board of directors were selected to serve on the national nominating committee: A. B. Cooper, B. D. Hull, W. B. Kouwenhoven, A. M. MacCutcheon, and C. E. Stephens.

The board confirmed the appointment by the president of P. M. Lincoln as a member of the Lamme Medal committee to fill a vacancy.

F. D. Newbury was reappointed a representative of the Institute on the Standards council of the American Standards Association for the three-year term beginning January 1, 1932; and H. H. Henline, A. M. MacCutcheon, and H. S. Osborne were appointed alternates for the year 1932. H. S. Osborne was appointed to act as alternate for any of the A.I.E.E. representatives on the Electrical Standards Committee. V. J. F. Brain, chief electrical engineer, Department of Public Works, Sydney, N.S.W., was appointed local honorary secretary of the Institute for Australia, to succeed H. W. Flashman, who is no longer located in Australia.

The following resolution was adopted in appreciation of the fourth gift to Engineering Foundation by Ambrose Swasey:

WHEREAS, Dr. Ambrose Swasey, Honorary Member of the A.I.E.E., has recently presented an additional fund of $250,000 to Engineering Foundation, which was founded in 1915 as a result of his vision and leadership, and to which he has now contributed a total of three-quarters of a million dollars for "the furtherance of research in science and engineering, or the advancement in any other manner of the profession of engineering, and the good of mankind," be it therefore

RESOLVED: That the board of directors of the American Institute of Electrical Engineers hereby expresses its deepest appreciation of Doctor Swasey's recent gift, a generous provision for the extension of the activities of the Foundation, and an admirable expression of his continuing faith in the importance of its accomplishments as well as its promise of even more important future contributions to the development of science and engineering.

The following resolution was adopted:

RESOLVED: That the board of directors hereby expresses its hearty appreciation of the effective services of the members of the District Meeting committee and its various subcommittees in arranging and carrying out, with gratifying success, the plans for the South West District meeting held in Kansas City, October 22-24, 1931.

Other matters were discussed, reference to which may be found in this and future issues of ELECTRICAL ENGINEERING.

Unemployment Relief Plans Well Under Way

THE following resolution, recommended by the A.I.E.E. committee on the economic status of the engineer, was unanimously adopted by the board of directors of the Institute at a meeting held in Kansas City, Mo., Oct. 23, 1931:

WHEREAS, it is desirable that the Institute cooperate in every movement that is already in progress to promote employment, and also to initiate within local communities a program that will contribute toward the relief of unemployed engineers;

RESOLVED: That this board recommends that each Section formulate and carry out a plan embodying substantially the following features:

1. The organization in each locality of a committee of engineers, preferably composed of representatives of all the engineering groups in the community.

2. This committee to collect and administer funds for purposes of loans and remuneration to deserving unemployed engineers.

3. A survey of the local engineers who are unemployed and in need of relief.

4. A survey of local opportunities for constructive work or employment, in which there may be utilized the services of the much larger group of unemployed, in addition to engineers; supported through the use of the community unemployment fund.

5. The preparation by the committee, by the aid of unemployed engineers as far as practicable, of engineering analyses, estimates, and organization requirements for such projects or work as the committee may endorse.

6. A forceful presentation by the engineers' committee of these projects to those in charge of the local civic unemployment activities, and the enlistment of their approval and financial support in promptly getting work started.

7. In carrying out the plan, each local Section of the Institute should work in close cooperation with local Sections of other national societies and with other local engineering groups; and, also, the general engineers' committee so organized should work in close cooperation with other local civic relief organizations.

8. In order that this plan shall be effective, it is essential that the local engineers' committees be carefully organized. A suggestion for such an engineers' unemployment committee is that it include some of the unemployed engineers, some good solicitors of funds, some good searchers for jobs, and some good organizers and administrators; and it is recommended that each committee have a chairman, a vice-chairman, a secretary, and treasurer, an executive committee to coordinate the work, a committee to administer the funds, make loans, arrange for remuneration to some of the unemployed engineers, etc., etc.

9. Each Institute Section is requested to keep the national committee on economic status of the engineer advised, through national headquarters in New York, as to progress and results obtained. The national committee, in turn, will endeavor to be of such aid as may be feasible.

It is the hope of the board that each Section will proceed, by cooperation with other sections of national societies and local engineering societies, if any, to organize in each community a single engineers' unemployment relief committee in accordance with the plan as outlined in the resolutions. To be effective, this program in behalf of unemployed engineers should be taken up vigorously and at once. Cities already organized in substantial accord with this resolution include Boston, Mass.; Chicago, Ill.; San Francisco, Calif.; and Toledo, Ohio.

In the metropolitan area of New York City, the American Society of Civil Engineers instigated activities to relieve unemployment. The Professional Engineers Committee on Unemployment Relief then was formed on the proposal of the A.S.C.E. that the four Founder Societies form a joint body to cope with the acute situation resulting from the large numbers of persons involved in that section.

The function of this committee is to find employment for professional engineers and to give financial aid to those actually in need. It is headed by H. deB. Parsons as chairman, and functions through an executive committee of which J. P. H. Perry is chairman, a financial committee with H. A. Kidder (F'29) as chairman, and a relief committee under the chairmanship of G. L. Lucas. Headquarters are in the Engineering Societies Building at 29 West 39th Street. Many members of the four engineering societies concerned are giving their personal time to the various phases of activity. Funds are being solicited for immediate relief and members are asked to help locate work for those still unemployed. A mass meeting attended by more than 800 engineers was held November 9 to acquaint members with the details of the plan and to inspire immediate action.

Faraday Centenary Meeting Well Attended

The memory of Michael Faraday was honored at a meeting held in the auditorium of the Engineering Societies Building, New York, N. Y., November 18, 1931. This meeting was under the auspices of the New York Museum of Science and Industry and was attended by about 700 persons.

Frederic B. Pratt, president of the museum, opened the meeting and called upon Dr. F. B. Jewett (F'12) to preside. Addresses were given by Prof. D. C. Jackson (F'12) head of the electrical engineering department of the Massachusetts Institute of Technology and Dr. Elihu Thomson (F'13-HM'28) director of research of the Thomson Laboratories of the General Electric Company. The subject of these addresses was the life and work of Michael Faraday. The meeting was arranged by the Faraday centenary committee of the museum, which consists of F. B. Jewett, chairman, G. F. Kunz, L. F. Loree, F. B. Pratt, C. W. Rice (F'12) C. R. Richards (M'24) M. S. Sloan (F'30) Frank A. Vanderlip, and Felix M. Warburg.

Standards

Mercury Arc Rectifiers

At the October 6th meeting of the A.I.E.E. standards committee, the report of the sectional committee on mercury arc rectifiers was received. This sectional committee, working under the rules of procedure of the American Standards Association and sponsored by the Institute, points out in its report that it appeared unwise to attempt to formulate rigid standards at this time.

After designs become fixed and greater operating experience is obtained, standards of a more rigid character will be made. The sectional committee found it necessary also to depart from the original set scope, and to confine its attention to metal tank rectifiers. There was no evident demand for standards for other types. The standards committee recommended to the board of directors the approval of the Institute as sponsor of the report. This approval was given on October 23, 1931. Upon final approval by the American Standards Association, this standard will become available in pamphlet form. Due notice will be given in a later issue of ELECTRICAL ENGINEERING.

Sound Measurement Committee Authorized

Following the Symposium on Noise presented at the A.I.E.E. North Eastern District meeting, Rochester, N. Y., April 29-May 2, 1931, recommendations were made to the board of directors that an Institute committee be appointed to cooperate with existing similar committees of several other organizations to develop uniform and practical standards for noise measurement. The matter was referred to the standards committee and at its October 6th meeting Chairman MacCutcheon was authorized to appoint the necessary contacting committee. Completion of the committee personnel is expected shortly, when work will get under way.

School Lighting Code Under Revision

The Illuminating Engineering Society has just issued in reprint form a revision of the Code of Lighting School Buildings prepared under the joint sponsorship of the Illuminating Engineering Society and the American Institute of Architects and adopted June 16, 1924, as an American standard under the procedure of the American Standards Association.

In this proposed new edition the primary purpose has been to establish criteria of good illumination for the guidance of architects, engineers, school officials, and others interested in the conservation of children's vision and the well-being and efficiency of both pupils and teachers.

This revision is now subject to approval by the sectional committee, the sponsors, and the American Standards Association, after which it will become available in pamphlet form. Inquiries and suggesttions should be addressed to American Standards Association, 29 West 39th Street, New York, N. Y.

Engineering Foundation

Progress Discussed at Recent Meeting

The October 22nd, 1931 meeting of The Engineering Foundation has been characterized as one of the most progressive yet held. A study of the present industrial system, as proposed by H. V. Coes of The American Society of Mechanical Engineers, the research activities and procedures of the Founder societies, and a new statement of the policy and program of the Foundation, were the principal subjects of the evening.

Two new members were announced: G. W. Fuller, consulting engineer, New York, N. Y., nominated by the American Society of Civil Engineers to succeed W. H. Burr, resigned; and G. G. Crawford, president of the Jones & Laughlin Steel Corporation, member-at-large, to succeed Alva C. Dinkey (A'97) deceased.

By invitation two members of each Founder society's main research committee discussed with the Foundation board a proposal made to the Foundation by the endowment methods committee of the United Engineering Trustees, for the establishment of a research procedure committee to aid the Foundation in ascertaining the research needs of the Founder societies and in making the best use of available resources for aiding the research activities of these societies. There were present from the civil engineers committee, Chairman C. T. Morris, professor of structural engineering, Ohio State University, Columbus, Ohio, and T. Merriman, chief engineer, Board of Water Supply, New York, N. Y.; from the mining engineers, F. F. Colcord, vice-president U.S.S. Lead Refinery, Inc. and F. E. Pierce, consulting engineer, New York, N. Y.; from the mechanical engineers, A. D. Bailey, superintendent of generating stations, Commonwealth Edison Company, Chicago, Ill., W. H. Fulweiler, chemical engineer, United Gas Improvement Company, Philadelphia, Pa., and C. B. Le Page, secretary of the committee; from the electrical engineers, H. D. Arnold (F'29) director of research, Bell Telephone Laboratories, New York, N. Y., and L. W. Chubb (F'21) director of Westinghouse Research Laboratories, Pittsburgh, Pa.

Interesting differences in the research policies, needs, methods and activities of the societies were brought out by the members of their respective committees. After discussion, there was endorsed unanimously the proposal for a research procedure committee attached to the Foundation, this committee to include one member from each Founder society annually selected from, or designated by, its main research committee, with two members from the Foundation board. The recommendation has been submitted to the boards of the Founder societies.

American Engineering Council

A.E.C. Plans Unemployment Relief

Plans to mobilize the nation's engineers behind President Hoover's program to end the depression were announced recently by the American Engineering Council. The Council will work with the relief organization already set up under the leadership of W. S. Gifford (A'16) president of the American Telephone and Telegraph Company, with an aim toward not only promoting emergency measures but also toward the development of sound, permanent employment policies throughout American industry.

A national committee has been appointed by the Council to direct the engineering efforts which will be carried out in detail by additional committees being named in each state. F. J. Chesterman (F'22) vice-president and general manager, The Bell Telephone Company of Pennsylvania, Pittsburgh, Pa., has been named chairman of the national committee with other members as follows:

Gen. R. C. Marshall, Jr. (M'19) vice-president in charge, B-W Construction Company, New York, N. Y. (in charge of construction division of the War Department during the World War); E. K. Ruth, American Oak Leather Company, Cincinnati, Ohio; W. R. Webster, Bridgeport Brass Company, Bridgeport, Conn.; and L. W. Wallace, executive secretary, American Engineering Council, Washington, D. C.

In a number of states, committees are already at work under the following chairmen: C. E. Rose (A'27) Little Rock, Ark.; F. C. Carstarphen, Denver, Colo.; Henry Robinson Buck, Hartford, Conn.; R. W. Prince, (M'30) Dist. of Columbia; Melvin Price, Gainesville, Fla.; R. F. Schuchardt (F'12 and past-president) Chicago, Ill.; Frank D. Paine, Ames, Iowa; Carl Schneider, New Orleans La.; Paul Cloke (M'13) Orono, Maine; F. A. Allner (M'14) Baltimore, Md.; J. P. Hallihan, Detroit, Mich.; Paul Doty (M'12) St. Paul, Minn.; W. M. Cobleigh, Bozeman, Mont.; O. J. Ferguson (F'13) Lincoln, Neb.; George W. Case, Durham, N. H.; C. A. Mees, Charlotte, N. C.; D. C. Henny, Portland, Ore.; F. F. Schauer, Pittsburgh, Pa.; R. W. Herrick (A'28) Providence, R. I.; J. A. McPherson, Greenville, S. C.; Mark Eldredge (M'20) Memphis, Tenn.; George A. Reed, Montpelier, Vt.; E. B. Norris, Blacksburg, Va.; and Joseph Jacobs, Seattle, Wash. Additional state chairmen are: G. M. Butler, Tucson, Ariz.; H. W. Hitchcock (M'27) Los Angeles, Calif.; R. A. Seaton, Manhattan, Kansas; Col. E. M. Stayton, Independence, Mo.; L. J. Bevan, Montclair, N. J.

Definite Plans Made

In a recent report by the committee it was stated most emphatically that "the immediate answer for unemployment is jobs; . . . the spreading of man-hours is the most essential expedient for stabilizing employment that can be suggested at the present time; . . . plans should be started immediately. . . toward lightening the consequences of any further or future unemployment." In line with these stipulations, the committee outlined a comprehensive program under which engineers individually and collectively can develop helpful measures of correction by carefully studying the problem in their respective employment areas.

It is planned to place special emphasis on the study of all proposed or active government projects, and to inform the public or take other action to insure construction being carried out properly and expeditiously. Attention will be devoted also to the development of a future plan to assist in stabilizing industry.

Board of A.E.C. Holds Fall Meeting

The fall meeting of the administrative board of the American Engineering Council held in Washington, D. C., October 30-31, 1931, devoted the full two days to a discussion of numerous problems important to the engineering profession. Among these matters, the progress report of the public affairs subcommittee was presented. The committee is of the opinion that there is urgent need for a general survey of conditions surrounding the transportation of persons and of property in interstate commerce. This survey has been proposed by congressional legislation. It is felt that this investigation should be made not by the Interstate Commerce Commission alone but by a body consisting also of men prominent in the government, and federal reserve system, as well as by representatives of railroads and shippers.

The administrative board adopted a policy relative to legislation concerning rivers and harbors, to the effect that legislation on all unapproved projects should be checked and reported to the committee of public affairs which would determine what action should be taken.

The board also voted to form a special committee to consider the intelligent integration of industry with agriculture not only as an emergency measure, but also as a possibility for future advancement.

St. Lawrence Project Reviewed

At its meeting, January 1931, American Engineering Council voted to appoint a committee to review the economic aspects of the report of the Institute of Economics, made by H. G. Moulton, C. S. Morgan, and A. L. Lee and entitled "The St. Lawrence Navigation and Power Project." C. E. Grunsky, Jr. and E. L. Grunsky were selected to undertake this work.

In this latter report which has just been rendered to American Engineering Council, Messrs. Grunsky found a number of instances in which they questioned the conclusions of the authors of the book.

A copy of the report prepared by C. E. Grunsky, Jr. and E. L. Grunsky may be had upon application to American Engineering Council.

Letters to the Editor

Mr. Edison's Greatest Work

To the Editor:

"A filament of carbon of high resistance" enclosed in a vacuum bulb hermetically sealed—the basis of his first demonstration in 1879 and of the foundation patent in 1880—with the collateral central station developments, around these will finally be written the Edison saga, for, regardless of the importance of his other inventions, the development and mastery of electric lighting by incandescence was Mr. Edison's most dramatic and difficult work, and its influence upon the modern electric age his most far-reaching one.

He did not originate the broad idea of parallel circuit distribution, or of getting light from an incandescent filament and enclosing it in a container, or even the use of carbon, but he was without question the creator of that type of construction which made possible his ideals of an individuality of use analogous to that provided in the existing gas, water and steam systems. To that objective he clung with extraordinary tenacity and courage over a long period beset with many failures and innumerable difficulties, and in the face of ridicule and a nearly unanimous opinion that the end he sought was unattainable.

As a juror at the Crystal Palace Exhibition in Suydenham in 1882, and in charge of special tests, I had an exceptional opportunity for first-hand knowledge, and my conclusions were voiced in a report made to the U. S. Navy Department in 1883, in the following words:

"In the matter of making the transmission of light and power a practical success, in bringing it home to every-day domestic economy, Mr. Edison, without doubt, has done more than all others, and while his system is by no means yet perfect it is unquestionably far ahead of the work of anyone else."

Mr. Edison was the apostle of a universal direct-current supply from central stations at moderate potentials, despite the inevitable limitations, and his individual work in the lighting field, which was his main objective, practically reached its climax in the middle '80's, when he announced his intention to develop "a new crop of inventions," and in 1888 resumed work on the phonograph, invented some nine years earlier. A year later his electric enterprises were consolidated in the Edison General Electric Company, with resultant transfer of most of his responsibilities.

But already the great advances of the succeeding decade, collateral indeed but made by other men, had been initiated and were in full swing. The constant speed industrial motor had been adopted by the Edison Companies in 1885, and the pioneer work at Richmond had laid the foundation of the modern electric railway. The advent of the single and multiphase alternating circuit systems of transmission and conversion of energy at high potential had made possible the utilization of water powers, and with the later development of the steam turbine laid the only possible foundation of the great modern power plants. Soon came also multiple unit train control, vital to mass movements by electricity.

Carbon has now been replaced by its predeces-

sor, the metallic filament; the vacuum, although it must first be got, is no longer a continuing essential; the gas lamp has opened new vistas of economy; and the alternating-current system has come into its own. But whatever the developments in the electric art and however wide the departures in practise, the vital fact remains that Mr. Edison established the first real central station for the general distribution of electricity, and his name has become a symbol for fertility of invention and untiring activity, with results which have made the world forever his debtor. He has indeed lighted the world.

Very truly yours,
FRANK J. SPRAGUE (F'12)
(Past-President of the A.I.E.E.
President, Sprague Safety Control & Signal Corp., New York, N. Y.)

Engineering Progess—1731-1931

To the Editor:

Complying with the Engineering Foundation desire for engineers' comments on the article on "Engineering Progress 1731-1931," I would like to say that I think Martin J. Insull in his contribution in your September issue has brought up a subject of exceptional importance.

All engineers are convinced that engineering knowledge and skill in the aggregate has been of greatest benefit to Mankind. On the other hand, there are some changes which resulted from engineering achievements and their application that produced quite opposite results. Chief amongst these, in my opinion, has been the shrinkage in size and commercial activity of small towns.

There is, I believe, no question that small towns having populations of from 3,000 to 7,500 people form ideal social, political, and industrial units. That many such towns have reduced importance and even less population today (as a result of massing of manufacture in large cities) is painfully evident.

If Mr. Insull and his affiliated interest and several large manufacturing organizations could work together and demonstrate that Mr. Insull is right as to the possibility and practicability of decentralizing much of our congested manufacturing by distributing it into present or new towns of ideal size and location it would, in my opinion, be of tremendous value to all people.

Of course Mr. Insull is right when he says that under present conditions power can be delivered in any desired amount practically anywhere one would care to develop a town. By working with several large manufacturing corporations such towns could be established any desired distance apart. If only five or ten miles apart, much of the extra overhead expense of superintendence of a small plant need not be appreciably more than in larger plants, for many of their superintendents easily could take care of four or five small plants so located if they all belonged to one corporation. By having in each town plants belonging to two or more corporations the diversified industry that is so desirable would exist in each.

In many cases, by such cooperative effort, old towns could be brought back and above their old standing; but my recommendation would be to build in most cases entirely new and modern towns. If skill were used in finding the best and most attractive locations they could be developed into something far more attractive than the present average town.

When one sees the immense difference between the average small town and the few ideal towns we now have (for instance Dalton, Mass. as built up by the Crane family around their paper mills) it is easy to see that success will be more certain if carried out with "whole cloth."

Assuming the present average power consumption to be about 4 kw. per employee in manufacturing plants, there would be required in a town of 5,000 people, 2,000 of which were working in its factories, some 10,000 kw. of transformer capacity, including domestic requirements. This is enough power to be economical in cost of equipment even if the supply is taken direct from 110-kv. or even 220-kv. transmission lines. If the cost were considered too great at 220 kv., then substations of 20,000-kw. capacity could be used by placing them midway between towns and the power be distributed at from 2.4 to 6.6 kv. to towns on either side.

A little progress has been made already, as we all know, in decentralization of manufacture, but the progress is likely to continue to be slow unless some competent central body skillfully directs the movement.

I think it would be highly desirable therefore, for the Engineering Foundation to appoint a special committee to study Mr. Insull's proposition and show what great things could be accomplished by such an effort.

A committee representing the utilities companies the large manufacturing interests and the architects would seem to be what is needed.

What greater gift could this generation of engineers present to the generations that are to follow, than to arrange so that some ten million or more, who under present practice are doomed to live and work in the congestion of great cities, could work and live in some one of 2,000 such new and delightful small towns.

Very truly yours,
WALTER S. MOODY (A'06, F'12)
(Consulting Engineer, Transformer Departments, General Electric Company, Pittsfield, Mass.)

Personal

Doctor Whitehead to be Awarded Medal

Electrical World Photo

J. B. WHITEHEAD

John Boswell Whitehead (A'00-F'12 and Life Member) professor of electrical engineering and dean of the faculty of engineering, The Johns Hopkins University, Baltimore, Md., is to receive the Elliott Cresson Gold Medal to be awarded by the Franklin Institute on May 18, 1932. This medal is to be conferred "in consideration of his many original investigations of dielectric behavior and allied subjects." *The Journal of the Franklin Institute* gives the basis of this award as follows:

"This medal is awarded for discovery or original research, adding to the sum of human knowledge irrespective of commercial value; leading and practical utilizations of discovery; and invention, methods or products embodying substantial elements or leadership in their respective classes, or unusual skill or perfection in workmanship."

The particular work which lies back of this award is the great amount of research which Doctor Whitehead has carried on during the past eight or ten years in the field of the fundamental properties of dielectrics as related to the behavior of insulating materials. This has covered gaseous ionization in laminated insulation, dielectric absorption in simple and complex materials, properties of liquid dielectrics, particularly the insulating oils, and the relation of these properties to the behavior of impregnated paper as used for high voltage cables. Responsible in a large measure for the advances made is the development of experimental methods for measuring the charge and discharge currents of dielectrics under continuous potential for very short intervals of time following the application of voltage. These continuous voltage measurements have been correlated with alternating measurements so that from the measurements of short time continuous voltage, the behavior of dielectrics under stress may be predicted completely as regards dielectric loss, power factor, and capacitance.

Doctor Whitehead has been active in Institute affairs for many years. He was the founder of the Baltimore Section and for nineteen years served as its chairman. From 1924 to 1928 he was a member of the board of directors of the Institute. He has served as chairman of the electrophysics committee 1912-1916, chairman of the research committee 1923-1927, and at various times as a member of committees on research, electrophysics, electrochemistry, code of principles of professional conduct, education, technical activities, and others. Since its inception he has been identified with the work of the committee on research.

The Institute selected him as its representative on the division of engineering and industrial research of the National Research Council, and as its delegate to the Conference Internationale des Grand Reseaux Electriques, Paris, France, 1927. In connection with the former he served as chairman of the committee on electrical insulation.

Practically every year since 1910 Doctor Whitehead has presented to the Institute one or more papers the aggre-

C. W. RICE

gate of these numbering thirty-two. The Institute publications have been practically the sole medium of publication for his work.

Doctor Whitehead is a Fellow of the American Physical Society, and a Member of the Society for the Promotion of Engineering Education, the National Institute of Social Sciences, the Societe Francaise des Electriciens, and the National Research Council. He was exchange professor to France 1926-1927. Honors awarded him include the Edward Longstreth Medal of the Franklin Institute, 1917, the Triennial Prize of the Institute Elektrotechnique Montefiore Liege, Belgium, 1922 and 1925, and the medal of honor of the University of Nancy, France, 1927.

Calvin W. Rice Honored by A.S.M.E.

A ceremonial to be given prominence on the program of the annual dinner of the American Society of Mechanical Engineers to be held on the evening of Wednesday, December 2, 1931, will be the bestowal of honorary membership in the society upon its secretary Calvin W. Rice (F'12), who for the past twenty-five years has worked with untiring diligence for its advancement both nationally and internationally, professionally, educationally, and civically. His achievements are too well known to require detailed delineation here. For these achievements and because he is considered by his confrérés to typify the finest attributes of the engineer, Doctor Rice has been chosen for honorary membership in this organization. The address of presentation will be made by Dr. Karl T. Compton, president of Massachusetts Institute of Technology, Doctor Rice's alma mater. Dr. William F. Durand (M'20) past-president of the A.S.M.E. will preside over the events of the evening, auspicious in the history of the organization and including the bestowal of four 50-year Badges of Honor upon other veteran members of the Society.

W. H. Sawyer (F'13) recently elected chairman of the executive committee of the Iowa Public Service Company, Sioux City Gas & Electric Company, and the Sioux City Service Company, will devote a portion of his time to active supervision of these properties. but will continue his consultant and sponsorship activities at his New York office, 120 Broadway.

W. N. Clark (A'05) vice-president and general manager of the Southern Colorado Power Company, Pueblo, Colo. has now been elected its president. His vice-presidency dates from 1924, and his work was instrumental in bringing together into one organization four of the leading electric companies in the Cripple Creek mining district.

C. G. Jones (M'18) has been acting as inductive heating engineer for Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., but recently has resigned to become special engineer for the Youngstown Sheet and Tube Company, Youngstown, Ohio.

P. Trombetta (A'21) on the first of October resigned from the research laboratory of the A. O. Smith Corporation of Milwaukee, Wis., to organize The Solenoid Company for the manufacture of electrical machinery and protective devices of divers types.

F. A. Kolster (M'19) formerly chief research engineer for the Federal Telegraph Company, Palo Alto, Calif., removed recently to New York, N. Y., where he will assume new duties with the International Communication Laboratories, Inc.

P. R. Farrow (A'07) who prior to November 15, 1931 was resident engineer for the Kaministiquia Power Company, Ltd., Kakabeka Falls, Ont., Can., now is manager of operations for the Ontario Power Service Corporation, Fraserdale, Ont., Can.

C. E. Baxter (A'22) telegraph and telephone engineer of the New York Central Railroad Company, Grand Central Station, New York, N. Y., has removed to Detroit, Michigan, to continue these services for the company there.

R. H. Ballock (A'25) manufacturers representative of the Central Station Equipment, Tacoma, Wash., entered the government's employ and is senior engineering draftsman in the Navy Department, Bureau of Engineering, Washington D. C.

W. R. Swoish (A'29) who has been salesman in the central station section of the Westinghouse Electric and Manufacturing Company, Buffalo office, has been transferred to the distribution transformer section, Sharon, Pa., as manager.

N. D. Russell (A'24) who has been performing the duties of superintendent of service and technical inspection for Electrical Research Products, Incorporated, Dallas, Texas, now is at Columbus, Ohio, as engineer for this organization.

R. B. Tenney, Jr. (A'10) engineer of the Texas Power and Light Company, Dallas, Texas, recently has become consulting engineer at Dallas for the Power Cost Engineering and Appraisal Corporation, San Antonio, Texas.

M. J. Mallery (A'30) formerly lighting specialist for the Westinghouse Electric and Manufacturing Company, St. Louis, Mo., now has joined the Steam Equipment Company, Memphis, Tennessee, in the office of secretary.

D. S. Nicol (A'14) who heretofore has been associated with Parsons, Klapp, Brinckerhoff & Douglas, Detroit, Mich., entered the educational field as professor of electrical engineering at Nova Scotia Technical College, Halifax, N. S.

Herman Ulanet (A'30) who was superintendent of the Federal Steel Products Company, Newark, N. J., now has been elected president of the George Ulanet Company, engineers and manufacturers in Newark, N. J.

H. E. Hoadley (M'26) who has been serving the Ohio Public Service Company as its superintendent of distribution at Warren, Ohio, recently became engineer for the Empire District Electric Company, at Joplin, Mo.

D. B. Taylor (M'27) previously resident engineer, Albany district, New York Power and Light Corporation, Albany, N. Y., has taken over the superintendency of the Schenectady (N. Y.) district of that company.

S. F. M. Wilde (A'30) who has been occupied as engineer assistant for Johnson & Phillips, Charlton, London, England, recently made new connections with Kennedy & Donkin, Withington, Manchester, Eng.

R. M. Arnold (A'25) who was chief engineer of the radio division, United Air Cleaner Company, Chicago, Ill., now is chief engineer of the radio division of the Grigsby-Grunow Company also of Chicago.

P. F. Meigs (A'31) previously erecting engineer for the Bucyrus Erie Company, South Milwaukee, Wis., now is assistant instructor, department of electrical engineering, University of Kansas, Lawrence, Kans.

S. N. Bose (M'22) inspection engineer, Cazenovia Electric Company, Cazenovia, N. Y. has gone to India to be chief electrical engineer of the Tata Iron & Steel Company, Ltd., at Jamshedpur.

E. deRziha (A'11) heretofore chief engineer of Siemens-Schuckertwerke A. G., Berlin, Germany now is identified with Société Continentale D'Electricité in Alger, North Africa.

R. R. Law (A'31) for the next two years will engage in graduate work at The Harvard Engineering School, Cambridge, Mass. Mr. Law has removed recently from Ames, Ia.

R. M. Bayle (M'21) general engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., now is engineer for the Westinghouse company at Chicago, Ill.

H. F. Jefferson (M'19) removed from Seattle, Wash., recently to become test engineer for the Jackson Bell Company, manufacturers of radios, Los Angeles, Calif.

C. H. Suydam (M'29) planning engineer for the Federal Telegraph Company, Palo Alto, Calif., has been transferred recently to the company's Newark, N. J. office.

J. L. Merrill (M'19) electrical engineer, Philadelphia, Pa., has undertaken a consulting practise in Jackson Heights, Long Island, N. Y.

Obituary

L. T. Robinson Dies November Third

Lewis Taylor Robinson (A'04—F'12) engineer in charge of the general engineering laboratory of the General Electric Company, Schenectady, N. Y., died suddenly at his home in Schenectady, November 3, 1931. His death was attributed to heart attack. He was 63 years old having been born in Springfield, Mass. Mr. Robinson early evidenced a fondness for mechanics, later leaning toward electricity, which was then just coming into practical usage. About that time Lynn became headquarters for the Thomson-Houston Electric Company; two years after the plant was started and when Lewis Robinson was seventeen years old, he was engaged there by E. W. Rice, then plant superintendent. Later Prof. Elihu Thomson took him out of the plant and made him his office assistant. His aptitude made for rapid progress and within a short time he was in charge of the company's standardizing laboratory and the calibration of fine instruments; in 1891, in partnership with G. A. Whitmore, he established a laboratory for electrical testing and the calibration of instruments. This company under the name of Whitmore & Robinson continued until 1893; then Mr. Robinson joined what was then the Schuyler Electric Company, at Middletown, Conn., later acquired by the newly formed General Electric Company. A year later he engaged with the Central Electric Company at Lewisburg, Pa., where he remained until in 1896 he joined the General Electric Company at Schenectady and became one of its chief organizers.

L. T. ROBINSON

For more than twelve years Doctor Robinson has devoted himself generously to Institute activities including active participation in more than thirty-five important committee assignments, several dealing with intersociety and international technical affairs. Three times he served on the Institute's board, twice as vice-president (1916-18, 1920-21) and once as manager (1913-16). Indicative of the wide scope of his active participation, a few of his committee memberships are mentioned: meetings and papers 1910-19 (chairman 1914-18); constitutional revision 1912-13; professional conduct 1912-13; editing 1912-14 (chairman) and 1916-17; standards 1914-27 and 1929 (chairman 1919-20); Edison Medal 1914-16, 1917-30, 1931; Sections 1918-19; coordination 1920-21 (chairman); instruments and measurements 1924-27. He was chairman of the Schenectady, N. Y., Section for the year 1915-16. A great many important subcommittees, particularly those of the standards committee, also received the benefit of Doctor Robinson's advice and counsel, and several important committee and subcommittee reorganizations were engineered by him. As an authorized A.I.E.E. representative he participated in the joint conference which the Founder societies held to organize the American Engineering Council, 1921; the radio standardization conference, 1922; a special committee on international standards, 1926; and the American Standards Association Council, 1929.

Doctor Robinson was the holder of more than thirty patents covering a wide range of electrical apparatus. In 1904 as collaborator in the electrical exhibit of the General Electric Company he received a silver medal awarded by St. Louis exposition. In 1929 Union College (Schenectady, N. Y.) conferred upon him the honorary degree of Doctor of Science as "inventor, engineer, musician." Music was his chief diversion; he promoted, assisted, and sometimes acted as conductor of the General Electric orchestra, and was recognized in musical circles as an artist of noteworthy ability.

He was a member of the Society of Engineers of Eastern New York, the American Physical Society, the National Electric Light Association, the American Association for the Advancement of Science, National Electric Manufacturers' Association, the United States committee of the International Electrotechnical Commission, and the American Standards Association.

George Milton Ogle (M'27) manager of the power and industrial department of the National Electric Power Company, New York, N. Y., and well known for his research work with regard to the effects upon the human system of

electric shock, died suddenly October 14, 1931. He was a native of Louisville, Ky., having been born there in 1888. In 1909 he became signal engineer for the Pennsylvania Railroad Company, two years later becoming chief draftsman for Heyward Brothers & Wakefield Company, at Wakefield, Mass.; in three years' time he advanced to the position of superintendent of power and machinery. Then he joined the Edison Electric Illuminating Company of Boston (Mass.) as commercial engineer, removing in 1916 to New York for similar services with the Edison Electric Illuminating Company of Brooklyn (New York). Two years later he became electrical and mechanical superintendent for the Massachusetts Chocolate Company of Boston, Mass., which was making a complete electrification of its Boston plant. As resident engineer of this company, Mr. Ogle then was given entire charge of the mechanical and electrical departments in the erection of a new million-dollar plant at Burlington, Vt. In April 1918, the Westinghouse Electric & Manufacturing Company chose him as general engineer at East Pittsburgh, Pa., where his work was principally in engineering for shipyards. He was appointed chief electrical engineer of the United States Shipping Board Emergency Fleet Corporation, and later held the same position with the Vulcan Iron Works, Inc., Jersey City, N. J. He then became power specialist for the General Electric Company, serving the company in both Schenectady and New York. In 1925 he was made consulting engineer for the General Engineering & Management Corporation, until joining the organization with which he was identified at the time of his death.

Cedric Samuel Anderson (A'21) electrical engineer of the Anaconda Wire & Cable Company, Hastings-on-Hudson, N. Y., and a postgraduate student at Columbia University, dropped dead as he was attending class there on the morning of November 13, 1931. He was 42 years of age, having been born at Boston, Mass., February 16, 1889. While practising engineering, he was studying for his master's degree. Mr. Anderson already held a degree of B.S. in E.E. conferred upon him by Massachusetts Institute of Technology in 1911, which was the year he joined the Telluride Power Company, at Telluride, Colo. Upon the consolidation of several companies to form the Western Colorado Power Company, he was appointed assistant to the general manager, three years later to be chosen as superintendent of the Clark Electric Power Company at Tooele, Utah. In 1919 he left this organization to become sales engineer for West Penn Power Company, Pittsburgh, Pa. soon to be requested to undertake the work of district superintendent; the following year he was promoted to power engineer. His removal to Hastings came subsequent to 1927, and rounded out an experience of twenty years of progressive engineering.

Isaac Newton Lewis (A'07) retired colonel of the United States Army, died suddenly of heart failure the afternoon of November 9, 1931, at Montclair, N. J., where he resided. He was 73 years old, his native city being Uniontown, Pa. Graduating with the West Point class of 1884, he pursued his military training by a course at the Graduate Torpedo School, Willetts Point, which he completed in 1886. Following this he was placed in charge of electrical installations at Fort Wadsworth, subsequently being given charge of the department of electricity, power and power transmission, U.S. Artillery School, Fort Monroe, Va. His inventive genius contributed many devices for both military and civil applications, among them, the Lewis portable, air-cooled machine gun, the first weapon to prove effective against zeppelins. While stationed at Fort Leavenworth, Kans. in 1888 he invented the first successful artillery range and position finder, a device which was accepted immediately by the War Department. He was a member of the American Association for the Advancement of Science, the Union League and the Lawyers Club of New York, the Army and Navy Club of Washington, D. C., the Montclair Athletic Club, and the Colonial Society of Montclair, N. J.

Charles Ernest Long (A'27) general electrician and hydroelectric power plant operator for the Puget Sound Power and Light Company's eastern district, Wenatchee, Wash., met his death October 11, 1931, in connection with a mine accident. Mr. Long, who was 45 years old, was born in Elkhorn, Manitoba, Canada. He served an apprenticeship with the Toronto General Light and Power Company, later starting an electrical contracting business of his own under the firm name of the Davidson Electric Company. In 1915 he enlisted with the 1st Pioneers of the Canadian Expeditionary Forces, electrical division, and in 1917 engaged with the Canadian National Railways, for the superintendency of all electrical construction west of Saskatoon. In 1925 he came to the United States from Alberta, Canada, being employed one year in Seattle as an electrician, and the following year taking up his work with the Puget Sound Light & Power Company Tumwater Canyon plant. Here he was employed until two years ago, when he was transferred to electrician at the Royal Development Company's mine, making his home at Leavenworth, Wash.

Jan D. Otten (A'90) electrical engineer, Amsterdam, Holland, and a Member for Life of the A.I.E.E., died in Amsterdam, September 29, 1931. Doctor Otten retired from active professional practise in 1926, the year in which he received his election to Member for Life. Some of his earliest engineering work was in affiliation with the general European office of the Thomson-Houston International Company, at Hamburg, where he was located at the time he joined the Institute as an Associate in 1890.

Local Meetings

District 1 Executive Committee Convenes at Schenectady

The fall meeting of the executive committee of the Institute's North Eastern District was held in Schenectady, N. Y., October 9, 1931. Present were: *chairman and District vice-president*, I. E. Moultrop (Boston, Mass.); *District secretary*, A. C. Stevens (Schenectady, N. Y.); *Section chairmen*, R. G. Warner (New Haven, Conn.); R. W. Graham (Buffalo, N. Y.); F. R. Finch (Pittsfield, Mass.); Wm. S. Maddocks (Providence, R. I.); F. C. Young (Rochester, N. Y.); R. A. Beekman (Schenectady, N. Y.); C. W. Henderson (Syracuse, N. Y.); *acting Section chairmen*, W. H. Colburn (Boston, Mass.); R. F. Chamberlain (Ithaca, N. Y.); H. A. Maxfield (Worcester, Mass.); *Section vice-chairman*, E. E. Johnson (Schenectady, N. Y.); *Section secretary* W. B. Hall (New Haven, Conn.). Also present by invitation were: *assistant national secretary*, H. H. Henline (New York, N. Y.); *past-vice-president*, H. M. Hobart (Schenectady, N. Y.); *Section committee chairman*, E. S. Lee (Schenectady, N. Y.).

Prof. R. G. Warner was elected to serve on the national nominating com-

mittee. J. A. Johnson, at present a director of the Institute, was unanimously nominated for District vice-president. In addition to the District vice-president, District secretary, and chairman of the Branch counselors executive committee, the following were nominated for membership on the District coordinating committee: R. G. Warner (New Haven, Conn.); R. W. Graham (Buffalo, N. Y.); J. P. McCann (Worcester, Mass.); and F. C. Young (Rochester, N. Y.).

After discussing the organization of the committee in charge of the 1932 District meeting at Providence, R. I., a motion was unanimously carried to the effect that the 1933 District meeting be held at Schenectady during the early part of May.

Competition between the students of the Pittsfield and Schenectady Sections and the interest which this competition created among the older as well as the younger men, was cited as increasing the interest in student activities. Various means of aiding students in their activities were discussed; among others was suggested that prizes might be offered for student papers, based on delivery and content. Before adjourning, Past Vice-president H. M. Hobart and Assistant National Secretary H. H. Henline expressed their appreciation of the meeting and commended the members for their activities.

District 5 Executive Committee Meets at Chicago

The annual meeting of the executive committee of the Institute's Great Lakes District was held in the rooms of the Western Society of Engineers, Chicago, Ill., on Monday, October 12, 1931. Present were: *president* and *District chairman*, T. N. Lacy (Detroit, Mich.); *District secretary*, A. G. Dewars (Minneapolis, Minn.); *District treasurer*, K. A. Auty (Chicago, Ill.); *Section chairmen*, F. R. Innes (Chicago, Ill.); J. J. Shoemaker (Detroit, Mich.); E. J. Schaefer (Fort Wayne, Ind.); E. L. Carter (Indianapolis, Ind.); N. H. Blume (Madison, Wis.); C. H. Kreuger (Milwaukee, Wis.); Oscar Gaarden (Minneapolis, Minn.); E. H. Waldo (Urbana, Ill.); *Section secretaries*, O. E. Hauser (Detroit, Mich.); C. M. Summers (Fort Wayne, Ind.); E. G. Thoms (Indianapolis, Ind.); L. F. Wood (Des Moines, Iowa); G. F. Tracy (Madison, Wis.); E. V. Lassen (Milwaukee, Wis.); E. H. Hagensick (St. Paul, Minn.); E. A. Reid (Urbana, Ill.); *acting chairman*, C. L. Sampson (Des Moines, Ia.); *acting secretary*, R. D. Maxson (Chicago, Ill.); *District committee on student activities chairman*, G. C. Knipmeyer (Terre Haute, Ind.) Visitors were: *District convention committee vice-chairman*, F. A. Kartak (Milwaukee, Wis.); and *technical program subcommittee chairman*, J. F. H. Douglas (Milwaukee, Wis.).

K. A. Auty was unanimously reelected as District treasurer. Mr. Auty also was nominated for the post of vice-president of the Institute from the Great Lakes District (No. 5). T. N. Lacy was elected a member of the national nominating committee representing this District in the coming election for Institute president.

In addition to the vice-president, secretary, and chairman of the District committee on student activities, the following were elected to serve on the coordinating committee: C. H. Kreuger (Milwaukee, Wis.); N. H. Blume (Madison, Wis.); F. R. Innes (Chicago, Ill.); and E. V. Lassen (Milwaukee, Wis.). A motion was passed that the past coordinating committee continue to serve as a part of the District convention committee, assisted by the new coordinating committee. The report of the District convention committee was read and a motion was carried inviting the board of directors to meet in Milwaukee during the coming District convention. Reports of Section activities were also made.

Means of increasing the Institute's membership, as well as interest in Section meetings, were discussed. A motion was passed that a tentative program of Section meetings be prepared early in the season and circulated to all other Sections in the District.

Chicago Power Group Holds Season's First Meeting

The first meeting this season of the Chicago Section's Power Group was held October 22, 1931, in the Engineers Building, Chicago, in joint session with the Electrical Section of the Western Society of Engineers.

A brief introductory address by F. R. Innes, chairman of the Section, was followed by a discussion by P. B. Juhnke and A. R. Lake of the Commonwealth Edison Company before an audience of some 160 persons. The subject was "Power System Operation in the Chicago District." Mr. Juhnke dedicated the meeting to Mr. Edison whose early inventions had made the power industry possible; Mr. Lake described in detail some of the actual problems of interconnected system operation, demonstrating with the aid of charts and diagrams the subjects of telemetering, power flow control, frequency control, reserve capacity, etc. A recent case of trouble due to lightning on the overhead lines of the interconnected system was described illustrating the real effectiveness of reserve capacity for preserving continuity of service.

Future Section Meetings

Akron

December 8, 1931—Television, by J. O. Perrine, American Tel. & Tel. Co. Meeting to be held in the auditorium of the Firestone Tire & Rubber Co.

January 12, 1932—X-Ray Inspection of Welds, by Ancel St. John, president, St. John X-Ray Service Corp. Movies: "Story of Steel." Meeting to be held in the auditorium of the Ohio Edison Co.

Chicago

December 2, 1931—Short-Circuit Calculations and Application of Oil Circuit Breakers, by W. C. Hahn, General Electric Co.

January 7, 1932—Control of Noise and Vibration in Station Design, by P. E. Stevens, Byllesby Engineering and Management Corporation.

Cleveland

December 17, 1931—Behind the Scenes, by Dr. Zay Jeffries, metallurgical engineer and consultant; W. L. Enfield, manager, incandescent lamp development laboratory. Both of these speakers are with the General Electric Co. at Nela Park. Joint meeting with the Illuminating Engineering Society.

January 21, 1932—Some Institute Problems, by Dr. C. E. Skinner, president of the A.I.E.E., and assistant director of engineering, Westinghouse Elec. & Mfg. Co.

Dallas

December 21, 1931—Social meeting.

January 18, 1932—General Developments of 1931. This subject will be covered by students of the Southern Methodist University Student Branch.

Detroit-Ann Arbor

December 1, 1931—Subject and speaker to be announced later. Meeting to be held at Detroit Edison Auditorium.

January 19, 1932—Ladies' night.

Lehigh Valley

December 11, 1931—Inspection trip to the central breaker of the Locust Summit District of the Philadelphia & Reading Coal & Iron Co. at 1:30 p. m. Dinner at the Necho Allen Hotel in Pottsville at 6:30 p. m. At 8 p. m. the following papers will be presented:

Electric Power in the Coal Fields and Its Application to Coal Mining, by W. H. Lesser, Penn Anthracite Mining Co.;

Field Tests of Circuit Breakers, by Prof. A. R. Miller, Lehigh University.

Louisville

December 18, 1931—The Engineer's Place in the Sun, by Prof. W. E. Freeman, University of Kentucky, and vice-president, Southern District No. 4, A.I.E.E.

January 22, 1932—Practical Application of Light Sensitive Cells, by J. U. Briesky, research engineer, Westinghouse Elec. & Mfg. Co.

Lynn

December 2, 1931—Ladies' night.

December 16, 1931—Lightning, by K. B. McEachron, General Electric Co.

January 6, 1932—Ladies' night.

January 16, 1932—Inspection trip to Loose Wiles Biscuit Co.

January 20, 1932—Local convention. Subject:—Centrifugal Air Compression.

Pittsburgh

December 8, 1931—Recent Developments in Electrical Research, by Dr. Phillips Thomas, research engineer, Westinghouse Elec. & Mfg. Co.

January 12, 1932—Some Institute Problems, by Dr. C. E. Skinner, president of the A.I.E.E., and assistant director of engineering, Westinghouse Elec. & Mfg. Co.

Seattle

December 15, 1931—Rural Electrification Meeting. Papers by Prof. G. S. Smith, Washington State College; and H. J. Gille, manager, agricultural and industrial development, Puget Sound Power & Light Co. H. V. Carpenter, vice-president, North West District No. 9, A.I.E.E. will give a talk on Institute affairs.

January 19, 1932—Presentation of papers submitted for annual prize competition. Titles and speakers to be announced later.

Vancouver

December 7, 1931—The Design of the Modern Radio Receiver, by V. W. M. Fouracre, Northern Electric Co., Ltd.

January 4, 1932—Subject and speaker to be announced later.

Past Section Meetings

Baltimore

The Canal Situation, by J. F. Stevens, consulting engineer, former chief engineer of the Panama Canal (1905-07). Mr. Stevens discussed the economics of a supplementary route through Nicaragua and pointed out that from all statistics available the Panama Canal is of sufficient capacity to take care of all shipping requirements for years to come. Joint meeting with the A.S.C.E. and A.S.M.E. Sections, and Engineers Club. October 22. Attendance 150.

Chicago

Power System Operation in the Chicago District, by P. B. Juhnke and A. R. Lake, both of the Commonwealth Edison Co. October 22. Attendance 160. (A complete report of this meeting is published in this issue under "Local Meetings" p. 982.)

Cleveland

In the afternoon, members and guests assembled at the dock of the "U.S.S. Akron" where an interesting lecture was given by one of the guides who described the dock and dirigible. Following this lecture, those present went to the laboratories of the Ohio Insulator Company where opportunity was afforded to inspect insulators of recent design. In the evening W. T. Van Orman, Goodyear Zeppelin Corp., spoke on Developments of Lighter-than-Air Craft. A. O. Austin, Ohio Insulator Co., gave a series of demonstration illustrative of new developments in high voltage phenomena. Joint meeting with the Akron Section. Members of the Cleveland Engineering Society invited. October 8. Attendance 376.

The Navigation of the Akron, by Lieut.-Commander C. E. Rosendahl, captain of the "U.S.S. Akron." By the use of motion pictures, the evolution of airship construction was illustrated from that of the first crude ship built by Count Zeppelin to that of the Akron. Joint meeting with the Cleveland Engineering Society and the Akron Section. October 13. Attendance 1,500.

Columbus

Television, Its Fundamental Physical and Psychological Principles, by J. O. Perrine, American Tel. & Tel. Co. This lecture was accompanied by demonstrations of the types of apparatus used in television. October 27. Attendance 154.

Connecticut

The Fundamentals of Radio Broadcasting, by Prof. W. J. Williams, Rensselaer Polytechnic Institute;

The Requirements of Radio Broadcasting on Communication Circuits, by H. W. Sundius, Southern New England Telephone Co. Following these talks there was an inspection of the WTIC studios in the Travelers Building and of the transmitter on Avon Mountain. October 28. Attendance 300.

Dallas

Construction of the Hamilton Dam on the Colorado River in Texas, by F. A. Dale, Emery, Peck & Rockwood Development Co. October 19. Attendance 115.

Denver

Some Thoughts on Waves, by O. B. Blackwell, American Tel. & Tel. Co. Dean H. S. Evans and Prof. R. E. Nyswander, chairman, gave reports of the summer convention held at Asheville, N. C., last June. Joint meeting with the Telephone Pioneers of America and The American Bell Club. October 16. Attendance 75.

Detroit-Ann Arbor

Recent Developments in Electric Heating, by H. J. Hall and G. Coley, both of the Detroit Edison Co. Illustrated by slides. J. J. Shoemaker, chairman, gave a résumé of the District executive committee meeting held in Chicago. October 12. October 20. Attendance 80.

Erie

Development and Uses of the Modern Oscillograph, by A. D. MacAffer, General Electric Co. Many interesting tests made on the oscillograph were shown. October 20. Attendance 75.

Fort Wayne

Contact Potentials and the Theory of Dielectrics, by Dr. Karl Lark-Horovitz, Purdue University. Illustrated with slides and blackboard sketches. October 15. Attendance 75.

Houston

Effect of Wave Form on Operation of Induction Type Protective Relays, by P. H. Robinson, Houston Lighting and Power Co. Dinner preceded the meeting. October 29. Attendance 23.

Indianapolis-Lafayette

The Relation of Frequency and Quality in Communication, by J. L. Wayne and E. R. Moore, Indiana Bell Telephone Co. This talk brought out the importance of frequency requirements in the transmission of speech,

music, and pictures. Demonstrations followed. Dinner preceded the meeting. October 16. Attendance 45.

Kansas City

Aims and Activities of the A.I.E.E., by Dean George C. Shaad, University of Kansas, and vice-president, South West District (No. 7) A.I.E.E. October 14. Attendance 54.

Building a Skyscraper, by G. O. Brown, Kansas City Power & Light Co.;

Conditions in Europe, by E. E. Howard, of Ash, Howard, Needles & Tammen;

Conquering the Missouri River, by Robert McDowell, student, A.I.E.E.

India, by Mundadhi Rau, student, A.S.M.E.

Joint meeting with the A.S.M.E. Section and the A.I.E.E. and A.S.M.E. Student Branches at the University of Kansas. November 5. Attendance 200.

Lehigh Valley

Inspection trip to the new hydroelectric project of the Safe Harbor Water Power Corp. October 3. Attendance 212.

Los Angeles

A Picture of Wave Motion, by O. B. Blackwell, American Tel. & Tel. Co. Illustrated with lantern slides. October 6. Attendance 103.

Louisville

Engineering Marching On, by Dean F. Paul Anderson, University of Kentucky. Short talk by Prof. W. E. Freeman, University of Kentucky, and vice-president, Southern District (No. 4,) A.I.E.E. October 30. Attendance 94.

Lynn

Three sound pictures were presented, "An Address by Dr. A. E. Kennelly, past-president of the A.I.E.E.," "Dr. W. D. Coolidge, Research Laboratory, General Electric Co., and his Cathode Ray Tubes," and "Mazda Lamps Preferred," followed by the serving of refreshments and an informal get-together of members present. October 21. Attendance 400.

Madison

Some Unique Electrical Heating Effects, by Prof. Edward Bennett, University of Wisconsin. Demonstrated. L. C. Larson, Section Delegate, gave a brief résumé of the 1931 summer convention held at Asheville, N. C. Dinner preceded the meeting. October 21. Attendance 45.

Memphis

Annual dinner meeting at which the following officers for the year 1931-32 were announced: W. A. Gentry, chairman; F. L. Christenbury, secretary; O. F. Long, treasurer, W. F. Bowld, M. Eldredge, and G. F. Leake, directors. Short talks by M. Eldredge, retiring chairman, W. A. Gentry, chairman, and W. R. Herstein, president, Memphis Chamber of Commerce. October 13. Attendance 40.

Minnesota

Electric Water Heating, by R. R. Herrmann, Northern States Power Co. Dinner preceded the meeting. October 28. Attendance 30.

Nebraska

Some Institute Problems, by Dr. C. E. Skinner, president of the A.I.E.E., and assistant director of engineering, Westinghouse Elec. & Mfg. Co. Doctor Skinner showed several reels of motion pictures that he had taken on a recent world tour. Dinner preceded the meeting September 28. Attendance 180.

Niagara Frontier

The X-Ray in Industry, by E. W. Page, General Electric X-Ray Corporation. Illustrated by slides and motion pictures. Dinner in honor of the speaker was held at the Hotel Niagara. October 16. Attendance 85.

Philadelphia

Modern Long Distance Telephone Communication, by A. P. Godsho, Bell Telephone Co. of Pennsylvania. An active discussion followed the presentation of this paper. October 12. Attendance 75.

Pittsburgh

The Modern Engineer, by S. M. Kintner, Westinghouse Electric & Mfg. Co. Joint meeting with the Engineers Society of Western Pennsylvania. October 21. Attendance 140.

Portland

Ariel Hydroelectric Development, by G. Wisting and O. L. LeFever, both of the Northwestern Electric Co. Mr. Wisting spoke on the construction of the Ariel plant and showed slides of pictures taken during that period. Mr. LeFever outlined the electrical and hydraulic features of the development. October 20. Attendance 62.

Inspection trip to the Ariel Hydroelectric Development. October 24. Attendance 45.

Rochester

The Engineer as a Citizen, by Roy V. Wright, managing editor, *Railway Age*, and president, A.S.M.E. Interesting discussion followed the presentation of this paper. Joint meeting with the A.S.M.E. Section and Rochester Engineering Society. October 1. Attendance 128.

St. Louis

Some Institute Problems and the Electrical Industry, by Doctor C. E. Skinner, president of the A.I.E.E., and assistant director of engineering, Westinghouse Electric & Mfg. Co. October 21. Attendance 65.

San Antonio

Army Air Corps Service, by Lieut. E. C. Lynch, instructor at Randolph Field. October 19. Attendance 37.

Saskatchewan

The Theory and Practise of Electrical Surveying, by Prof. T. Alty, University of Saskatchewan. Illustrated by slides. October 16. Attendance 22.

Seattle

The Engineer and the Community, by J. Frank McLaughlin, Puget Sound Power & Light Co. Annual dinner meeting. September 15. Attendance 86.

E. E. Fellows, General Electric Co., outlined problems which confronted the *Seattle Times* when it moved from a d-c. area to an a-c. area. K. L. Howe, Westinghouse Elec. & Mfg. Co., discussed the problem of maintaining the proper temperature of the molten metal in linotype machines. Wallace Quistorff, Puget Sound Power & Light Co., described the power supply arrangements for the *Seattle Times*. The meeting then adjourned to the Times Building for an inspection trip through the plant. October 20. Attendance 76.

Sharon

Simplified Practise and Standardization, by R. E. Hellmund, Westinghouse Elec. & Mfg. Co. November 3. Attendance 95.

Southern Virginia

Friday evening, October 30: Meeting opened with address of welcome by J. H. Berry, chairman. Motion pictures illustrating the four stages of power generation and the turbo-electric driven President Coolidge followed. Prof. W. S. Rodman, University of Virginia, introduced Dr. C. E. Skinner, president of the A.I.E.E. and assistant director of engineering, Westinghouse Electric & Mfg. Co., who spoke on Pioneers and Pioneering. Attendance 139.

Saturday, October 31: Murray J. Idail, manager of engineering, Virginia Public Service Co., described the new Bremo Bluff Plant of that company. An inspection trip to the Bremo Bluff Plant in the afternoon was preceded by luncheon at the William Frank Hotel in Fort Union, Va. Attendance 50.

Spokane

Inspection trip through the Fox Theater. The heating and ventilating

system was described by the engineer in charge, and the projection and sound equipment, as well as the lighting effects, were described and demonstrated by operators in the projection booth. October 30. Attendance 55.

Springfield

CARRIER CURRENT STREET LIGHTING CONTROL, by Ralph E. Curtis, United Electric Light Co. Illustrated by slides. September 14. Attendance 52.

WELDING, by Prof. C. A. Adams, Harvard University. October 13. Attendance 44.

Toledo

UNDERGROUND CABLE PRACTISE, by F. L. Calvert, General Electric Co. October 16. Attendance 45.

Toronto

WATERWHEEL GOVERNING, by A. Kalin, Woodward Governor Co. Interesting discussion followed. October 9. Attendance 105.

SURGE ABSORBERS, by J. M. Thomson, Ferranti Electric, Ltd. Slides were shown illustrating absorbers used for the protection of meters, cables, and transformers, and the damage done to transformers by surge voltages. October 23. Attendance 111.

Urbana

ALADDIN UP-TO-DATE, by H. D. Sanborn, General Electric Co. Illustrated by lantern slides describing some of the achievements of the research laboratory, with particular reference to the development of the vacuum tube. October 15. Attendance 80.

Business meeting. October 23. Attendance 11.

Utah

RELAY PROTECTION, by Felix Guenther, Utah Power & Light Co. Reports of the summer and Pacific Coast conventions were given by Prof. A. LeRoy Taylor, Dr. J. Hugh Hamilton, and Dr. H. T. Plumb. October 12. Attendance 47.

Vancouver

PARTICULARS OF PLANT AND EQUIPMENT ON THE EMPRESS OF JAPAN, by C. Hayden, chief electrician, "Empress of Japan." This meeting was held on board the Empress of Japan and those present inspected the ship at the conclusion of Mr. Hayden's address. October 5. Attendance 100.

THE LOIS RIVER POWER DEVELOPMENT, by S. A. Perrot, S. A. Perrot & Co.;

DETERMINATION OF PLANT EFFICIENCY RUSKIN GENERATING STATION, by C. W. Colvin, B. C. Electric Railway Co. Ltd. November 2. Attendance 62.

Washington

THE ECONOMIC ACTIVITIES OF RUSSIA, by Prof. D. O. Kinsman, Catholic University of America. Professor Kinsman described his experiences during a 5,000 mile trip through Russia. Dinner in honor of the speaker preceded the meeting. October 13. Attendance 125.

Worcester

INTERESTING EFFECTS IN TRANSFORMER CONNECTIONS, by Prof. T. H. Morgan, Worcester Polytechnic Institute. October 22. Attendance 40.

Past Branch Meetings

University of Akron

LIFE OF MICHAEL FARADAY, by Philip Syracopoulos, student. Frank Marcinkoski elected chairman. October 7. Attendance 19.

THE LIFE OF CHARLES AUGUSTUS COULOMB, by Daniel Coorsh, student;

THE PRINCIPLES OF TELEVISION, by Harmon G. Shively, student. October 28. Attendance 11.

Alabama Polytechnic Institute

Smoker. Prof. W. W. Hill, counselor, gave a talk on the benefits of student enrolment in the Institute. September 17. Attendance 56.

T. E. Curtis, student, gave a report of the operation of the Georgia Power Company's plant near Atlanta. October 8. Attendance 15.

H. H. Altman, student, gave a talk on some of his experiences while employed at the N.B.C. studios in Chicago, Ill. W. H. Mims, chairman, outlined the inspection trip made by the senior students to several of the power plants of the Alabama Power Co. October 28. Attendance 11.

University of Alabama

Election of the following officers: Robert Lake, chairman; Fisher Allen, vice-chairman; Wood-Rowe Purcell, secretary; Irving Rosenblatt, treasurer. October 6. Attendance 11.

Film—"Insulated Wires and Cables." October 19. Attendance 34.

Armour Institute of Technology

Committee appointments announced. Talks were given by the officers to promote interest in the Branch activities. October 16. Attendance 50.

ELECTRON TUBES IN INDUSTRY, by L. L. Ludwigsen, General Electric Co. October 23. Attendance 60.

University of British Columbia

LOIS RIVER HYDROELECTRIC PROJECT, by R. W. Klinck, student;

LINE STARTING EQUIPMENT FOR LARGE SYNCHRONOUS MOTORS, by L. Williams, student. October 6. Attendance 17.

MERCURY ARC RECTIFIERS, by P. D. ROSSITER, student;

LIGHTNING, by H. M. Van Allen, student. October 20. Attendance 14.

Inspection trip to the Seymour Exchange of the B. C. Telephone Co. October 31. Attendance 12.

AN AUTOMATIC SMOKE TESTER, by G. E. Barnes, student;

THYRATRON TUBES, by J. N. McRae, student.

Film—"The Wizardy of Wireless." November 3. Attendance 28.

Brooklyn Polytechnic Institute

HOW THE DIAL TELEPHONE WORKS, by E. J. Kane. Bell Telephone Laboratories, Inc. Illustrated. October 20. Attendance 32.

California Institute of Technology

ELECTRICAL ADVERTISING AND SOME OF ITS APPLICATIONS TO INDUSTRY, by Mr. Prosser. October 30. Attendance 29.

University of California

THE LIFE OF EDISON, by Louis Rockholt, student;

EDISON AS AN INVENTOR, by Harold Wright, student;

EDISON AS A PERSONALITY, by Forrest Taylor, student.

Two films were shown, as follows: "Edison as a Benefactor" and "Edison as He is Today." October 7. Attendance 61.

AMATEUR RADIO, by Clayton Bane, American Radio Relay League;

RELATION OF THE RADIO AMATEUR TO THE RADIO INDUSTRY, by A. H. Babcock, Southern Pacific Co.;

BEAM TRANSMISSION, by Donald Hall, student. Demonstration of the transmitting and receiving of radio messages at 80 meters. October 21. Attendance 81.

Carnegie Institute of Technology

THE A.I.E.E. AND THE ENGINEER, by Prof. William R. Work;

THE STUDENT AND THE INSTITUTE, by Prof. B. C. Dennison;

HISTORY OF THE C.I.T. STUDENT BRANCH, by Prof. G. M. Porter, counselor. October 14. Attendance 40.

Case School of Applied Science

AN ENGINEER VISITS EUROPE, by Prof. H. B. Dates, counselor;

ELECTRICAL SAFETY DEVICES, by J. C. Elder, student.

W. J. Lattin, chairman, gave a summary of the activities at the District meeting held in Pittsburgh March 1931. October 22. Attendance 39.

Catholic University of America

Election of the following officers: Ralph Brady, president; Joseph DeBettencourt, vice-president; James Springmann, treasurer; Robert F. Bourne, secretary. Talk by Prof. T. J. MacKavanagh, counselor, on the purpose of the A.I.E.E. and its benefits to the student. October 21. Attendance 38.

University of Cincinnati

Business meeting. October 12. Attendance 3.

Clarkson College of Technology

Summer experiences were outlined by Prof. A. R. Powers, counselor, and H. Beck and O. C. McNairn, students. October 16. Attendance 24.

Colorado State Agricultural College

Prof. H. G. Jordan and Prof. F. L. Poole, counselor, gave talks on the activities of the Institute and the Student Branch. October 26. Attendance 24.

University of Colorado

The Advanced Course in Electrical Engineering at the General Electric Company, by Professor Palmer. October 7. Attendance 50.

The Madden Dam Project, by H. F. McPhail, U. S. Bureau of Reclamation. Illustrated with slides. October 21. Attendance 60.

Carrier Wave Telephone Circuit, by A. S. Anderson, General Electric Co. November 4. Attendance 90.

University of Denver

Cosmic Rays, by W. Overbeck, student;

Apparatus Used on Cosmic Ray Expedition at Summit Lake, by Paul Barth, student. October 13. Attendance 13.

Film—"Life of Thomas A. Edison." October 26. Attendance 23.

Drexel Institute

Radiation, by E. K. Cliver. October 15. Attendance 26.

Automatic Telephone Switching Equipment, by L. W. Temple, Jr., student. Inspection trip to the Radcliff Exchange of the Bell Telephone Co. of Pa. Dinner preceded the meeting. October 29. Attendance 32.

Duke University

Edison's Life, by Mr. Weaver, student;

Many Inventions of Edison, by Mr. Debrunny, student.

Prof. W. J. Seeley, counselor, outlined Edison's accomplishments and told of his acquaintance with him during the World War. November 4. Attendance 19.

University of Florida

General discussion of activities for the coming year. October 7. Attendance 28.

G. R. Shafto, Graybar Electric Co., spoke on the trend and development of radio broadcasting. October 19. Attendance 60.

Systems of Street Lighting and Control, by Harvey F. Pierce, student;

Story of the Frequencies, by G. D. Beck, instructor. November 2. Attendance 27.

Georgia School of Technology

Film—"Electric Heat in Industry." October 13. Attendance 75.

University of Idaho

Picnic. September 29. Attendance 30.

University of Illinois

Discussion of activities for future meetings. September 23. Attendance 21.

Social gathering and entertainment. September 30. Attendance 150.

Business meeting. October 7. Attendance 65.

Film—"The Benefactor." October 21. Attendance 45.

Iowa State College

Why Electrical Engineers Should be Affiliated with Their Own Professional Organization, by Prof. F. E. Johnson, counselor. October 7. Attendance 288.

Some Aspects of Power and Communication Systems Affecting Inductive Coordination, by Mr. Carl and two assistants, Northwestern Bell Telephone Co. October 28. Attendance 205.

University of Iowa

Election of the following officers: David Marchant, president; Francis Murray, vice-president; Albert Behnke, secretary-treasurer. September 23. Attendance 45.

Superheterodyne Receivers, by Elwin O'Brien, student. September 30. Attendance 43.

Lightning Disturbances to Power Lines, by I. Piercy, student;

Movietone Films, by L. Travis, student. October 7. Attendance 41.

Current Events, by Ralph Spafford, student;

Parallel Operation of A-C. Generators, by John Weland, student. October 21. Attendance 42.

Kansas State College

Election of the following officers: G. E. Cain, president; E. R. Jensen, vice-president; L. R. Schruben and C. L. Brown, secretaries; W. S. Hemker, treasurer; N. J. Kling, assistant treasurer; D. E. West, corresponding secretary.

The Eye, by Dr. Evans. October 1. Attendance 50. (Evening session.)

The program of the afternoon meeting was the same as that presented in the evening. October 1. Attendance 68.

University of Kentucky

A Review of the Life of Edison, by Z. Pigue, student;

The Life of Faraday, by Thompson Bonzo, student. October 28. Attendance 41.

Lafayette College

Election of following officers: Henry H. Jones, chairman; G. D. Hegeman, Jr., secretary-treasurer.

L. J. Conover, counselor, explained the aims and activities of the A.I.E.E. October 22. Attendance 18.

Lehigh University

The Manufacturing and Testing of High Tension Insulators, by L. B. Huntington, Jr., student;

Automotive Electricity, by G. A. Burn, Mack International Motor Truck Corp. October 15. Attendance 70.

Lewis Institute

Prof. F. A. Rogers, counselor, outlined the privileges and advantages of student enrolment in the Institute. Election of the following officers: L. P. Evans, chairman; H. May, secretary-treasurer. October 22. Attendance 43.

Louisiana State University

Election of the following officers: P. W. Stokeley, chairman; B. F. Marx, vice-chairman; E. R. Wilkinson, secretary. October 17. Attendance 20.

University of Louisville

Relays, by C. B. Eldredge, student. Henry K. Friedman elected secretary. October 9. Attendance 21.

Massachusetts Institute of Technology

Inspection trips to the Milk Street Manual Exchange and Toll Center, and Kenmore Commonwealth Automatic Exchange, both of the American Tel. & Tel. Co. October 20. Attendance 21.

The Relation of Engineering Education to Industrial Careers, by R. I. Rees, assistant vice-president, American Tel. & Tel. Co. Moving pictures and dinner followed this address. October 23. Attendance 250.

Michigan College of Mining and Technology

Three films presented, as follows: "The Life of Thomas Edison," "Trip Through General Electric Works at Schenectady," and "Behind the Lines." October 16. Attendance 56.

J. S. Francis, student, outlined a trip he had taken to several industrial plants

in Detroit and emphasized the part played by electricity. October 30. Attendance 26.

Michigan State College

E. W. Moore, chairman, outlined the advantages of student enrolment in the A.I.E.E. October 13. Attendance 19.

Life of Thomas A. Edison, by Carl Stringer, student. Accompanied by a film describing the development of the electric lamp. October 27. Attendance 19.

University of Michigan

The Aims and Purposes of the A.I.E.E., by Prof. S. S. Attwood, counselor. Election of the following officers: Gary Muffly, chairman; R. W. Rockefeller, vice-chairman; John M. Lyon, secretary; Z. C. Lansdale, treasurer. October 15. Attendance 46.

Some Aspects of the Thermal Problem in Electrical Design, by C. J. Fechheimer, Westinghouse Elec. & Mfg. Co. October 31. Attendance 85.

School of Engineering of Milwaukee

Election of the following officers: A. Oklund, president; Gale Young, vice-president; Robert Stephenson, secretary; A. Pflieger, treasurer.

Prof. V. M. Murray stressed the advantages of student enrolment in the Institute.

Trends in Engineering Education, by Dr. J. D. Ball. October 14. Attendance 134.

University of Minnesota

Prof. J. H. Kuhlmann, counselor, gave a talk on the purpose, aims, and activities of the A.I.E.E. and the student Branch. October 22. Attendance 16.

Mississippi A. & M. College

Plan and Purpose of the A.I.E.E., by Dean L. L. Patterson, counselor. Committee appointments announced. October 1. Attendance 30.

Film—"The Single Ridge." October 26. Attendance 26.

University of Missouri

Carrier Current Communication Over High Voltage Lines, by J. E. Shepherd, chairman. October 14. Attendance 31.

Montana State College

Report of the Pacific Coast convention by H. T. Lambdin, chairman. October 1. Attendance 126.

The following papers were presented by students:

Tungsten Bows to the Plating Bath, taken from *Scientific American*, presented by Charles Anderson;

Welding Stresses are Relieved in the Electric Furnace, taken from *Electric Journal*, presented by Herbert Archibald;

Saluda Hydroelectric Development (from *Electric Journal*) presented by Harry Beck;

Sales Talk for General Electric Review, by Everett Blanchard;

Airplane Flight Aided by Electricity (from *Electric Journal*) presented by Eric Blannin;

Producing Noises from Power Transformers, by Arthur Buckley;

Whole World Helps Build Electric Generators (from *Journal of Electric Workers and Operators*) presented by Edgar Dolum;

Development of Gaseous Tube (from Electrical Engineering) presented by Leonard Estey. October 8. Attendance 117.

Graduate Training for Engineers, by Dr. James Tryon, Massachusetts Institute of Technology. October 15. Attendance 120.

The Story of Edison's Life, by Wesley Funk, student;

Edison's Achievements, by Armin Hill, student. October 22. Attendance 109.

The following papers were presented by students:

Speed Street Car for Dresden (from *Railway Journal*) presented by Helmer Fallman;

Stabilization of Industry (from *G. E. Review*) presented by Edward Fisher;

Growlers for Armature Testing (from *Electric Journal*) presented by James Garrison;

Free Wheeling Street Cars (from *Electric Traction*) presented by Vern Hankins;

Dampers Installed on Hot 110-Kv. Line (from *Electrical West*) presented by Curtis Hanson;

Cylinder Pressure Indicator (from *Electric Journal*) presented by Edward Hughes;

Biography of Alman B. Strowger, by Roderick MacDonald. October 29. Attendance 115.

Newark College of Engineering

Electrical Show. October 9. Attendance 158.

Demonstration and lecture by S. P. Grace, assistant vice-president, Bell Telephone Laboratories, Inc. October 21. Attendance 200.

Inspection trip to South Amboy power station. October 23. Attendance 32.

Europe — Engineering Observations, by Prof. Paul M. Giesy. November 2. Attendance 31.

University of New Mexico

History and Development of the X-Ray Tube, by A. W. Francis, student;

Theory and Explanation of the X-Ray Tube, by H. Mendenhall, student. October 13. Attendance 20.

General discussion of Branch activities. Martin Zirhut elected vice-chairman. October 15. Attendance 10.

Austin True, chairman, gave a description of the District meeting held at Kansas City. October 28. Attendance 9.

College of the City of New York

General discussion. October 1. Attendance 13.

New York University

The History, Organization, and Activities of the A.I.E.E., by H. H. Henline, assistant national secretary, A.I.E.E. September 29. Attendance 27.

The Life of Michael Faraday, by R. D. Nussbaum, student. October 14. Attendance 16.

North Carolina State College

Purpose and Aims of the A.I.E.E., by G. E. Ritchie, chairman;

Advantages of Membership in the Student Branch, by Professor R. S. Fouraker, counselor. October 6. Attendance 25.

Design and Economics of Distribution Systems, by Mr. Roewe, Carolina Power & Light Co. November 19. Attendance 55.

Setting Poles in Florida with Dynamite, by J. E. Whitehead, student. Film—"The Electric Ship." November 3. Attendance 27.

University of North Carolina

Education by Observation, by Prof. G. T. Schmenning. October 19. Attendance 60.

North Dakota State Agricultural College

Fred Payne elected chairman and Orville Isley, vice-chairman. October 2. Attendance 11.

The State College Engineer, by Rae Taylor, student;

The Student Branch of A.S.M.E., by Leonard Lynstad, student;

The Student Branch of A.I.E.E., by Fred Payne, chairman;

The Importance of Mathematics to Engineering, by Mr. Hartwell, instructor;

Scenes of Constantinople, by Prof. W. E. Smith. Joint meeting with the A.S.M.E. Branch and the Engineers Club. October 8. Attendance 106.

Life of Edison, by Oliver Blecken, student. Film—"The Story of Rail Steel." November 5. Attendance 63.

University of North Dakota

First meeting of the season held to discuss plans for future meetings. September 30. Attendance 15.

Prof. H. F. Rice, counselor, gave a résumé of the summer convention held at Asheville, June 1931. October 14. Attendance 15.

University of Notre Dame

Experiences in Engineering World Since Graduation from College, by Mr. Moyer, General Electric Co. October 5. Attendance 54.

Electric Light and Power in the United States, by Mr. Dietrich, Indiana-Michigan Electric Co.;

Mercury Arc Rectifier, by Francis Joseph, student;

Life of Michael Faraday, by Julian Quinn.

Current news presented by Jack Scanlon. October 19. Attendance 74.

Service Interruptions, by W. D. Stamm, Twin Branch Power Plant;

Television, by William Mitsch, student;

Why I Chose Electrical Engineering, by Joseph Doherty, student.

Current news presented by Jack Scanlon, student. November 2. Attendance 74.

Ohio State University

Smoker. October 8. Attendance 51.

Ohio University

G. B. Wychoff, chairman, gave a talk on the advantages of student enrolment in the Institute. Charles C. Colombo elected secretary. October 14. Attendance 24.

Oklahoma A. & M. College

Michael Faraday, by Paul Ratliff, student. October 1. Attendance 19.

Joseph Henry, by Clyde Wyant, student. October 8. Attendance 27.

Prof. A. Naeter, counselor, Paul Ratliff, J. Hutchins, chairman, and V. Smith described the District meeting held in Kansas City in October. October 26. Attendance 26.

Oregon State College

Charles Boyle, Aluminum Company of America, gave a summary of the growth of the aluminum industry during the past 40 years, and pointed out the number of recently found uses for aluminum. The three following films shown: "Blasting a Pre-Cast Dam Into Place," "Construction of the 132-Kv. Line from San Bernardino, Calif., to Hoover Dam," and "Construction of the 110-Kv. Line from Rock Island, Washington, to Skykomish, Washington." October 27. Attendance 77.

University of Pittsburgh

Election of officers as follows: R. A. Hartley, chairman; R. J. Campbell, vice-chairman; J. W. Stirling, Jr., secretary. September 23. Attendance 36.

Professor H. E. Dyche, counselor, outlined the purpose and activities of the A.I.E.E. September 25. Attendance 127.

Development of Vacuum Tubes, by R. Kertz, student;

Power from Tropical Seas, by H. S. Long, student. October 1. Attendance 125.

Mr. Goebel, Westinghouse Elec. & Mfg. Co., gave a talk on a Mediterranean cruise and a comparison of European manufacturing methods with those in the United States. October 8. Attendance 125.

Fokker Aircraft Construction, by W. L. Kaiser, student;

The Electric System, by L. W. Moline, student. October 15. Attendance 119.

Pratt Institute

Discussion of activities for future meetings. October 15. Attendance 22.

Automatic Control of Load and Frequency as Applied to Hydroelectric Stations, by R. Neumann, student. H. P. Miller, of the School of Science and Technology, spoke on the importance of the A.I.E.E. in the engineering profession and the advantages of student enrolment. October 22. Attendance 48.

Purdue University

Prof. C. F. Harding gave a talk on the history and activities of the A.I.E.E. with particular reference to the Student Branches. October 6. Attendance 200.

Rensselaer Polytechnic Institute

Talks on experiences during summer employment were given by seven students. October 13. Attendance 144.

Rice Institute

Film—"Buried Sunshine." October 14. Attendance 17.

Film—"Conowingo." October 28. Attendance 11.

General discussion. November 4. Attendance 27.

Inspection trip. November 6. Attendance 19.

Rose Polytechnic Institute

Election of the following officers: John Montgomery, president; Paul Froeb, secretary-treasurer. October 8. Attendance 18.

Professor C. C. Knipmeyer, counselor, outlined the history, purpose, and benefits of the A.I.E.E. October 21. Attendance 38.

A Student's Attitude Toward His Work, by James Payne, read by Charles MacGillvary, student. October 28. Attendance 39.

Rutgers University

Smoker and organization meeting. Election of officers as follows: Frederick Fisher, president; Floyd Taylor, vice-president; Lucas V. Banta, secretary; Harold Measly, treasurer. September 28. Attendance 27.

University of Santa Clara

Application of Aluminum to Transmission Line Construction, by Howard Fly, Aluminum Co. of America. Illustrated. Joint meeting with the A.S.M.E. Branch. October 15. Attendance 109.

University of South Carolina

Appointment of executive, meetings and papers, publicity, and membership committees. October 8. Attendance 10.

South Dakota State School of Mines

Harold Jepson elected secretary and Roy Full elected vice-chairman. September 29. Attendance 26.

University of Southern California

Dean P. S. Biegler, chairman, Los Angeles Section, gave a brief survey of the work carried on by the Sections and stressed the importance of students taking an active part in Branch activities. September 16. Attendance 31.

F. G. Philo, Southern California Edison Co., Ltd., gave an illustrated lecture on the development of the present steam plant at Long Beach, Calif. September 23. Attendance 35.

T. M. Blakeslee, Bureau of Water & Power, gave an illustrated talk on the development, design, and uses of the oscillograph, showing the various types of multiple element units. September 30. Attendance 30.

Interconnections between Substations and between Different Power Companies, by W. W. Austin, student. October 7. Attendance 25.

Industrial Application of the Photoelectric Cells, by Edwin W. Morris, Westinghouse Electric & Mfg. Co. October 14. Attendance 31.

Stanford University

M. R. Jones, Jr., chairman, gave a résumé of the Pacific Coast convention held at Lake Tahoe, in August. October 15. Attendance 30.

Stevens Institute of Technology

Prof. Kenneth S. M. Davidson gave a talk on yacht design. Luncheon served before the meeting. Election of officers as follows: Fernley L. Fuller, chairman; Robert A. Chadburn, secretary. October 30. Attendance 45.

University of Tennessee

The Largest Metered Transformers, by E. D. Jones, student. Demonstration of high voltages given by Professor J. G. Tarboux, counselor. October 21. Attendance 40.

Texas A. & M. College

Vacuum Tubes, by C. C. Nash, student. Election of the following officers: R. L. Suggs, chairman; E. Bartel, vice-chairman; G. H. Samuels, secretary-treasurer. October 20. Attendance 45.

Texas Technological College

Atmospheric Electricity, by Charles E. Houston, student. October 15. Attendance 15.

University of Utah

How Does the College Education Pay? by Mr. Huntsman. October 15. Attendance 25.

University of Vermont

Static Electricity, by G. S. Flagg, student. Demonstrated. October 12. Attendance 18.

Virginia Military Institute

The Life of Clerk Maxwell, by J. M. Trossbach, student;

Wind Rotor Generators, by J. B. Taylor, student;

The Economic Side of Public Utilities, by L. B. Jones, student;

The Life of Joseph Henry, by E. L. Kostainsek, student. Prof. S. W. Anderson, counselor, supplemented this paper with some interesting facts concerning, his experiments and his contemporaries. October 24. Attendance 70.

Film—"The Building of the 'U.S.S. Akron,'" November 5. Attendance 94.

Virginia Polytechnic Institute

Insulation of Electrical Apparatus, by S. S. Brown, student. J. V. Burgess, student, gave a report on the Signal Corps of the U.S. Army. October 22. Attendance 38.

Life of Thomas A. Edison, by J. R. Perrine, student;

Research Work in the Electrical Field, by R. P. Hankins, student. October 29. Attendance 43.

Vacuum Tube Millivoltmeter, by W. Richardson, student;

Dial Telephone System, by D. E. Young, student. November 5. Attendance 56.

University of Virginia

Prof. W. S. Rodman, counselor, gave a talk on the history, aims, and purpose of the A.I.E.E. and student enrolment. October 19. Attendance 10.

State College of Washington

Introduction of officers, and report on Pacific Coast Convention. October 1. Attendance 38.

University of Washington

Skagit Project, by Glen H. Smith, City of Seattle, Department of Lighting. Illustrated with slides and motion pictures. October 9. Attendance 20.

The Aspects of Commercial Engineering, by H. M. Gustafson, General Electric Co. October 15. Attendance 24.

Electrical Contracting, by Clifford Johns, student. October 22. Attendance 15.

Telephone Plant, by G. L. Larson, Pacific Telephone & Telegraph Co. October 29. Attendance 24.

Three films shown, as follows: "The Electric Ship," "Beet Sugar Production," and "Conquest of the Cascades." November 5. Attendance 20.

Washington University

Discussion of Branch activities. October 8. Attendance 27.

Business meeting. November 7. Attendance 16.

West Virginia University

The following talks were presented by students:

D-C. Power Transmission, by Kenneth DeMoss;

Bottling Electric Heat, by Morgan Sprigg;

3,600-R.P.M., 60-Cycle, Two-Pole Alternators, by E. L. Engle;

Conowingo Hydroelectric Development, by G. E. Hervey;

Synchronized Films, by V. S. Montieth;

Cylinder Pressure Indicators, by G. L. LeFevre;

Construction of Vacuum Tubes, by R. R. McCue. October 12. Attendance 30.

The following talks were presented by students:

Electrical Resistance Strain Gauge, by S. J. Iaquinta;

Benjamin Garver Lamme, by C. L. Barton, Jr.;

Series Street Lamp Cut-Out, by J. Kayuha;

Testing and Changing Insulators in Service, by P. Skaff;

Lighting System in Detroit City Airport, by D. C. Kennedy. October 19. Attendance 30.

University of Wisconsin

Film—"Glimpses of the Orient." October 6. Attendance 75.

Commercial Engineering, by J. K. Affanasiev, student. October 20. Attendance 55.

University of Wyoming

General discussion of activities for future meetings. October 15. Attendance 12.

The Functioning of the Short Wave Transmitter, by Roy Perkins, student. October 20. Attendance 10.

Life of Edison, by F. W. Wickenkamp, student. Illustrated. G. H. Sechrist, counselor, gave a talk on the activities of the A.I.E.E. November 3. Attendance 23.

Employment Notes

Of the Engineering Societies Employment Service

Men Available

ELECTRICAL ENGINEER, graduate, married, 28, with wide experience in industrial plant, electrical construction and maintenance; railway electrification; power plant design, estimating, and supervisory construction. Experience with electric contractor; cost analysis. Desires position with future. C-4428.

RECENT GRADUATE, age 21, single, citizen, good health, Protestant, B.E.E. degree, drafting and clerical experience, organization work. Would like to locate with a firm dealing with illumination or radio. Location, East. C-9756.

EXECUTIVE-MANAGER, public utility property. Technical education, construction, operating, management. Past six years consultant, executive engineer with foreign utility. Previous ten years with nationally known holding company interests. Available immediately. C-4036.

ELECTRICAL ENGINEER, B.S. in E.E. in cooperative college, age 23, experience in radio tube research, physical laboratory tests on synthetic resinoids, and electrical drafting. Desires position in any part of U.S. C-9978.

DISTRICT SALES MANAGER or manufacturer's agent: experienced engineering representative, desires connection with high grade company that has line of industrial or utility equipment. Eastern location preferred. B-4067.

1931 GRADUATE of five year cooperative school in electrical engineering. E.E. degree, age 23, single. Cooperative experience includes machine shop practise, telephone central office trouble shooting, and experience with large municipal fire alarm system. Desires position with manufacturing concern or public utility. Willing to start at bottom. Location, Middlewest preferred, but elsewhere satisfactory. C-9825.

1931 ELECTRICAL ENGINEERING GRADUATE, Midwest university, 23, single. Three months' experience with large public utility. Desires position with any manufacturing firm or public utility. Best of references. Location, immaterial. C-9984.

OVERHEAD DISTRIBUTION ENGINEER, economic cutting of losses, economic transformer spacing, economic wire size, correct voltage, will more than save your company the cost of my salary. Let me show you how I can make your distribution system more economical and efficient. Twenty years' experience. Speaks Spanish, married. United States preferred. C-2453.

FINANCIAL ENGINEER, Cornell (M.E.-E.E.). Twelve years regulator commission; four with utility holding management corporation; eight months intensive course bond buying department leading insurance company; employed almost four years thereafter on financial and fact-finding investigations by outstanding consulting engineering organization. Desires opportunity New York City. Salary open. C-2953.

GRADUATE OF STEVENS INSTITUTE OF TECHNOLOGY, 1931, in mechanical engineering, age 23, and single. Has had experience in communication, electrical installation, test and maintenance for eight years. Conscientious, practical, and willing to do any sort of engineering work. C-9976.

1931 GRADUATE ELECTRICAL ENGINEER, 29, 3 years' cooperative experience with

eastern public utility, 5 years' drafting and tool design experience before beginning college course. Single now, married when permanent position obtained. Desires position offering some contact with engineering work. Available on one week's notice. Location, anywhere. C-9834.

GRADUATE ELECTRICAL ENGINEER, 24, B.S. in E.E. Knowledge of design, construction of indicating instruments, also knowledge of electron tube. Two year cooperative course with Weston Electrical Instrument Corporation, (32 departments including shop, office and engineering work). Three years' industrial work before college. Available immediately. Location, United States, Canada. C-9585.

ELECTRICAL ENGINEER, Stanford University 1929; one year Westinghouse Course, six months' experience in manufacturing plant, development and design; nine months' experience in materials testing laboratory, engineering mechanics section, bureau of standards. Desires position in research work in physics or electrical engineering. Available immediately. C-8618.

GRADUATE ELECTRICAL ENGINEER, 22, single. Five years electrician's helper and electrician, experienced on small lighting plants and water systems, six months as machinist, five months Westinghouse Test covering switchboards, circuit breakers, and detailed apparatus. Desires position relating to power generation and distribution. Location, immaterial. C-9981.

ELECTRICAL ENGINEER, 22, single, 1931 technical graduate desires work. Four summers' operating experience in large paper mill. Will go anywhere, speaks Russian. D-23.

ELECTRICAL ENGINEER, married, age 29, graduate B.S. in E.E. 1925, six years' experience in engineering and drafting work with a prominent engineering firm, thoroughly familiar with power station and substation work, both physical and wiring. Desires position with public utility, or manufacturer of electrical equipment. Available immediately. D-22.

GRADUATE ELECTRICAL ENGINEER, married, 34, G. E. Test, and ten years' experience in the utility field, particularly in engineering and maintenance work of underground distribution systems, including a-c. low voltage networks. Desires position with utility in Middlewest or South with responsibility for design or maintenance of distribution system. C-1191.

ELECTRICAL ENGINEER, single, 1928 graduate, G. E. Test. Some power plant and railway substation installation experience, also qualified as radio operator. Considerable experience with mercury arc rectifiers and automatic switchgear. Would prefer position with consulting engineer, or similar firm. D-13.

GRADUATE ELECTRICAL ENGINEER from northern college of cooperative type; B.S. in E.E., 23, single, Protestant. Considerable machine shop and construction experience, automotive practise; two years in cooperative G. E. Test Course, control equipment. Seeking opportunity in engineering design and development. Location and salary secondary to opportunity. Available short notice. D-36.

ELECTRICAL ENGINEER, 32, single, E.E. graduate 1922. Westinghouse Graduate Student Course including electrical design school. Six years' experience induction motor design. One year industrial sales and two years application work on power house auxiliary electrical equipment. Desires position as design, application or sales engineer. Available immediately. Location, immaterial. C-9947.

GRADUATE ELECTRICAL ENGINEER, 24, single, B.S. in E.E., W.P.I. 1931. Four years' experience in construction; one year's experience in transmission work. Desires work in any electrical engineering field. Available at once. Location, optional. D-45.

ELECTRICAL CONSTRUCTION ENGINEER, graduate Case School of Applied Science 1928, age 27, married. Three and one-half years' experience with large electrical contractor in estimating, design, control work and field supervision. Excellent references. Middlewest location preferred. Available immediately. D-46.

SALES ENGINEER, B.S. in E.E. 1926, 27, single, experienced indicating instruments, utility purchasing department, test department, G. E. meter laboratory, radio sales and service, and retail store management. Desires a connection with a future. Location, immaterial. C-9045.

ELECTRICAL DESIGNING ENGINEER, 36. Six years power plant and preliminary studies, for standardization of indoor and outdoor substations. Six months power construction work. Two years drafting, standardization of factory planning and electrical equipment. Two years inspection and testing, of electrical equipment. Desires connection with consulting engineers. New York City preferred. D-14.

GRADUATE ELECTRICAL ENGINEER, 32, married, nine years' experience, research and development of small electrical devices and instruments. Some experience in the construction of photoelectric tubes, light valves and cathode ray oscillographs. Considerable experience in telephone, radio and railway signaling development. Available on two weeks notice. Location in Chicago preferred. D-58.

GRADUATE ELECTRICAL ENGINEER, 32, single, B.S. degree in E.E. Three years Westinghouse Test, seven years supervising power plants, substations and transmission line construction. Eight years engineering inspector, purchasing, expeditor, resident engineer and writing specifications. Excellent reference. Desires connection with holding company, utility, contractor or manufacturer. Available immediately. Location, immaterial. B-9661.

ENGINEER, Electrical, 37, native American, experience:—industrial mills, drives, lighting, generation, control, protection, underground distribution and some transmission, also design, field work, writing of specifications and calculations. Immediate placement anywhere very urgent; and salary can be easily arranged to the satisfaction of interested party. Willing to learn new phase. B-3172.

ELECTRICAL ENGINEER, Pratt graduate 1928, age 24, single. Three years' telephone experience. Knowledge of long and short haul circuit layout, cable including gas pressure protection, underground circuit and pole line construction, economic studies, estimating and technical photography. Available immediately. Location desired, New York City or vicinity. D-59.

ELECTRICAL ENGINEER, 29. University graduate, degree of B.Sc. 1923. Two years' experience with large management and engineering company in Middlewest. Six years' experience with nationally known electrical manufacturing company in sales, design and production departments. Desires position with manufacturing company. Available on short notice. Location, Eastern states preferred. C-9995.

GRADUATE ELECTRICAL ENGINEER, 1929, single, age 23. Fifteen months as student engineer on G. E. Test. Some test, drafting, and switchboard construction experience before graduation. Interested in position with concern doing consulting or construction work or with utility or manufacturer. Available at once. Location anywhere in United States. C-8028.

1931 GRADUATE of cooperative college. B.S. in E.E. Age 22, single. Six months' experience with manufacturing company, three months of plant maintenance and fifteen months with public utility. Desires position with any manufacturing, utility or engineering concern. Location, immaterial. Available at once. D-40.

M. I. T. GRADUATE ELECTRICAL ENGINEER, 35, married. Six years' industrial and teaching experience in electrical engineering. Several years private research and development work on own initiative. Good ability, integrity, and personality. Desires university teaching position for life work. Location preferred, Middlewest or South. C-2826.

DISTRIBUTION SUPERINTENDENT, age 46. Twelve years' experience as superintendent of distribution and transmission also metering equipment with public utilities in Central and South America. Spanish spoken fluently. Available now, unemployed. B-9642.

UNIVERSITY OF MAINE GRADUATE, B.S. in E.E., 1929, single, 23, 2½ years drafting, railway signaling. Desires any engineering position. Prefers illuminating engineering or teaching. Location, immaterial. Available immediately. D-65.

ELECTRICAL ENGINEER, 38, married. Seventeen years' experience, design, construction and inspection. Qualified to take complete charge of project from preliminary cost analysis work to finish of construction. Last assignment as superintendent of construction on $20,000,000 electrical and mechanical project. Willing to travel. Salary commensurate with position. Available immediately. B-4456.

SALES EXECUTIVE OR ENGINEER: Graduate electrical engineering and business administration. Three and one-half years sales manager with largest concern in its industry. Two years salesman and branch manager. Five years as engineer in public utility field. Has sales promotional and advertising experience. Would also consider purchasing position. Available immediately. B-7954.

ENGINEERING EXECUTIVE, 33, electrical and mechanical graduate, ten years' experience in management, design, construction, production, accounting, and sales, with steel mill, manufacturer, and utility, desires position as chief engineer, works manager, or other executive capacity where a calm, judicial disposition coupled with initiative and aggressiveness will show up in results. C-1297.

ELECTRICAL ENGINEER, 26, single, E.E., two years' public utility experience in construction, distribution, tests of equipment and domestic appliances, and investigations of abnormal conditions. Three years' clerical experience in cost of production. Can handle responsibility. Desires position with public utility, contractor, or manufacturer. References. Location, immaterial. Available immediately. D-47.

ELECTRICAL ENGINEER, E.E. degree, 36, single. Fourteen years' experience public utilities covering valuation work, rate investigations, engineering power plants, substations, transmission lines, including estimates, specifications, design. Experience covers short-circuit studies, stability analysis, investigations of systems for load conditions. Desires position, holding company, operating company, or consulting engineer. Available immediate. C-9570.

ELECTRICAL ENGINEER, 45, married, graduate of Virginia Polytechnic Institute, 1909, B.S. in E.E. Twenty-three years' experience with the Bell System and the International Telephone and Telegraph Corporation in telephone central office equipment design and planning for toll, manual and automatic dial operations. D-48.

ELECTRICAL MECHANICAL ENGINEER, six years' varied design, construction and operating experience on electrified railroads; familiar with valuation work and the design of transmission lines, catenary systems, substations and motive power. American, college graduate, membership in A.S.M.E., A.I.E.E., A.E.R.E.A., A.R.A. Wishes position anywhere with consulting firm, power company, railroad or manufacturer. C-8463.

ELECTRICAL ENGINEER, university graduate, 1910, experience principally in power and light electrical engineering. Desires position offering similar or electric railway experience. Eastern location preferred. B-1923.

TRACTION ENGINEER, 28, single, five years' experience electric traction shops as inspector, since then and at present in charge of service of the Southeast on registers. Two years at Georgia Tech., later graduated in electrical engineering from I. C. S. Was radio operator. Desires position as assistant engineer for electric traction. D-80.

ELECTRICAL-MECHANICAL ENGINEER, graduate of M.I.T. 1919. Competent, resourceful, sincere. Eleven years' experience in telephone circuits, radio retailing and manufacturing, sound equipment design. Desires mechanical development design in similar fields or research work in the application of vacuum tubes to voice or allied channels. C-310.

ELECTRICAL ENGINEER, 30, married, Wisconsin graduate. Two years construction; Westinghouse Course, two years traction engineering; one year appraisals; four years industrial engineering sales development work. Broad knowledge various industries. Special preparation in economics. Desires employment in surveys for financial or commercial firm; investigations; industrial sales; power sales. Location, East, Middlewest. C-3082.

ELECTRICAL ENGINEER, 27, single, experienced in estimating, detailing and layout of substations, transmission, and distribution lines. Also relay testing. Desires position with utility or engineering concern. Location, immaterial. D-89.

GRADUATE COMMUNICATIONS ENGINEER, Purdue, 1930. Age 24, married, experience with the communication problems of railway service. Familiar with Western Union and Bell System service. Also considerable practical work with control equipment, instrument repair and maintenance, and with radio. Location, immaterial. Available on short notice. D-88.

GRADUATE ELECTRICAL ENGINEER, 35, married, 12½ years' experience in low

tension equipment and signaling devices. Thoroughly familiar with devices involving time element and controlling apparatus for special applications. Has had designing and manufacturing experience. Location, immaterial. Will accept foreign appointment. Available at once. C-3820.

GRADUATE ELECTRICAL ENGINEER, 33, married, 3 years radio telegraph, 9 years supervision standardization involving: Distribution system materials, construction, generating stations, substations, special equipment, material design, insulation coordination, simplified practises in purchasing, etc. Desires position, sales, distribution, cable; industrial simplified practise; general engineer where practical inventive, developmental ability is required. Prefers Midwest, Southeast. D-44.

DESIGN ENGINEER, native American, age 33, married, technical education, industrial and mining experience, steam and Diesel power plants, auxiliaries, automatic substations, ability to handle men, can write specifications, knowledge of concrete and steel design, air compressor and ventilation installations. Location, Central U.S.A. preferred. C-9849.

SUPERINTENDENT of distribution, 44, married. Graduate Lowell Institute School, Auspices Massachusetts Institute Technology, electrical, industrial management courses. Twenty years' electric utility operating experience; engineering, construction, operation, maintenance of distribution, transmission lines, substations, transportation, first aid, educational works. Has sufficient public utility operating experience to qualify for position of superintendent. C-8411.

1931 GRADUATE IN ELECTRICAL ENGINEERING, B.S., Worcester Polytechnic Institute, single, 22. Desires connection with manufacturing or public utility concern. Location and salary secondary, experience, primary consideration. C-9627.

GRADUATE IN ELECTRICAL ENGINEERING, 1931, age 26, single, has B.S. in E.E. One year of electrical testing with large utility company. One year of electrical drafting of power and control switchboads. Three years' work in practical electricity. Interested in construction and supervision of small plants. Available at once. Location, anywhere. C-9457.

ELECTRICAL ENGINEER, married, university graduate, E.E., M.E. Twenty-two years' experience, designing, construction power plants, substations, transmission, distribution systems, industrial plants. Three years' executive experience charge engineering department large utility syndicate. Three years charge purchasing engineering equipment, foreign interests. Reads, speaks fluently English, German, Russian, Turkish languages. Available immediately. D-84.

ELECTRICAL ENGINEER, 33, married, B.S. E.E. 1921. Ten years automotive maintenance. G. E. Test. Three years designing a-c., d-c. motors, generators, arc welding equipment, control. Three years developing, designing d-c. motors, generators, control for automotive drive. Three years automotive development, maintenance bus, cab company. Interested, electrical automotive, design, maintenance. D-95.

ELECTRICAL ENGINEER, 25, single, B.S. in E.E., 1931, desires work. Interested in manufacture of electrical machinery or radio. D-97.

GRADUATE ELECTRICAL ENGINEER, young, single. Electrical and accounting education. Journeyman electrician experienced in industrial and commercial construction. Also two years with public utility engineering division. Desires position with industrial or contracting concern or with sales organization. Location, foreign or Western U.S., isolated plants satisfactory. D-96.

ELECTRICAL ENGINEER, age 45, technical school graduate, desires position with railway, industrial plant or consulting engineer. Twenty-four years' experience with large street railway and electrical contractor on designing, estimating, construction, and operation, electrical and mechanical. Has had considerable executive responsibility. Conversant with power reports and new projects. Prefer East. C-7202.

ELECTRICAL-MECHANICAL ENGINEER with metallurgical knowledge. College graduate with post-graduate study. Age 30, married. Westinghouse design training. Six years' experience design electrical circuits and mechanical details of control apparatus, specialized in elevator equipment. Interested in alloy welding research. Location, immaterial. Available on short notice. C-9638.

ELECTRICAL ENGINEER, 1931. Slight experience in vacuum tubes, and their application, also with resistor units. Sales experience in radio, telephone and sound systems. Desires position in research, radio, television or sound. Available now. C-5636.

SALES EXECUTIVE ENGINEER, electrical and mechanical training, seven years' sales engineering and executive experience in application of precision equipment to electrical equipment. Would like opportunity to develop sales of mechanical product allied with electrical industry or of electrical nature sold to central stations and industrials. Willing to tackle difficult job. C-5431.

COMMUNICATION ENGINEER, 31, single. Experienced telephone, radio installations; design, development of testing equipment for telephone, radio, sound picture circuits; design, use of semi-full automatic testing circuits to eliminate human element in testing; industrial applications of photoelectric cells, thermionic tubes. Best references as to professional ability, personal integrity. Location immaterial. Available immediately. C-9376.

Membership

Recommended for Transfer

The board of examiners, at its meeting of October 20, 1931, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Fellow

Carhart, Frank M., partner, Jackson & Moreland, Boston, Mass.

To Grade of Member

Giese, Raymond C., division plant engr., American Tel. & Tel. Co., Denver, Colo.
Higson, Charles R., supt. of distribution, Utah Pr. & Lt. Co., Salt Lake City, Utah
Hughes, M. C., acting head of elec. engg. dept., Texas A. & M. College, College Station, Texas
Putman, Henry V., manager, transformer engg. dept., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Rode, Norman F., professor of elec. engg., Texas A. & M. College, College Station, Texas
Smith, Robert P., sales engr., Westinghouse Elec. & Mfg. Co., Jacksonville, Fla.
Tabb, Warner T., consulting-technical writing, Gloucester, Va.
Tangie, Alexander A., chief installation inspector, electricity dept., Town Hall, Sydney, N. S. W., Australia

Applications for Election

Applications have been received by the secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the secretary before December 31, 1931.

Ackerman, C. D., Peerless Bread Machine Co., Sidney, Ohio
Addy, J. G., Jr. (Member) Marc Eidlitz & Son, New York, N. Y.
Andujar, M. K., Philadelphia Business Progress Association, Philadelphia, Pa.
Ashmore, O. B., Dallas Power & Light Co., Dallas, Tex.
Actzine, A. D., Canadian & General Finance Co., Ltd., Toronto, Ont., Can.
Ayers, E. H., General Electric Co., Schenectady, N. Y.
Bassiliades, D., University of Wisconsin, Madison, Wis.
Baum, W. U., Pennsylvania Power & Light Co., Northampton, Pa.
Baumann, G. H., Pennsylvania Railroad, New York, N. Y.
Baumgartner, C. W., Kansas City Pr. & Lt. Co., Kansas City, Mo.
Becker, D. E., Marquette University, Milwaukee, Wis.
Bixby, W. H., University of Michigan, Ann Arbor, Mich.
Book, C. F., Hydro-electric Power Comm. of Ontario, Niagara Falls, Ont., Can.
Boren, J. S., 412 Mercedes Ave., Pasadena, Calif.
Bosman, I. A., Board of Public Works, Holland, Mich.
Boulavin, L. B., Brooklyn Edison Co., Brooklyn, N. Y.
Bourne, R. D., Dallas Power & Light Co., Dallas, Tex.
Bretschneider, M. E., Kansas City Power & Light Co., Kansas City, Mo.
Brotzman, E. S., American Tel. & Tel. Co., Charleston, W. Va.
Brown, J. G., 127 Montgomery St., San Francisco, Calif.
Brown, W. B., 63 Forest Ave., Hawthorne, N. J.
Bruncke, H. P., Northern States Power Co., St. Paul, Minn.
Brusa, A. L., R. F. D. No. 1, Waterford, Conn.
Byrne, J. F., Ohio State University, Columbus, Ohio
Capon, A. E., 1224 Oberlin Drive, Glendale, Calif.
Chia, Y., 151 Scotland Road, South Orange, N. J.
Conroy, E. G., American Tel. & Tel. Co., South Bend, Ind.
Craig, W. D., Jr., Duquesne Light Co., Pittsburgh, Pa.
Crain, R. A., Southwestern Gas & Electric Co., Shreveport, La.
Cramond, R. B., New York Edison Co., New York, N. Y.
Crosby, L. W., 12 Elmwood Rd., Swampscott, Mass.
Crowell, D. C., General Cable Corp., Emeryville, Calif.
Crowson, F. B., Jr., American Tel. & Tel. Co., Shreveport, La.
Cummings, H. F., General Electric Co., Fort Wayne, Ind.
Danziger, S., 709 East 9th St., New York, N. Y.
Darley, W. G., General Electric Co., Cleveland, Ohio
Dawson, J. A., The Ohio Bell Telephone Co., Columbus, Ohio
Dial, G. T., New York Edison Co., New York, N. Y.
Di Toro, M. J., Brooklyn Polytechnic Institute, Brooklyn, N. Y.
Dudley, B., Institute of Radio Engineers, New York, N. Y.
Eastman, F. H., Jr., General Electric Co., Schenectady, N. Y.
Ellett, R. T., The Virginian Railway, Christiansburg, Va.
Engvall, L. R., Vega, Wash.
Erdos, E. J., Third Ave. Elec. & Supply Co., New York, N. Y.
Fager, C. R., General Electric Co., Los Angeles, Calif.
Farren, G. H., General Electric Co., Los Angeles, Calif.
Ferns, J. H., Stanford University, Stanford University, Calif.
Folsom, R. A., The Ohio Bell Tel. Co., Columbus, Ohio
Fort, R. I., 326 St. Clair St., Frankfort, Ky.
Franklin, W. S., J. E. Fast & Co., Chicago, Ill.
Frick, C. H., Valparaiso University, Valparaiso, Ind.
Ganzer, E. A. W., 12924 Division St., Blue Island, Ill.
Gardner, E. R., General Electric Co., Schenectady, N. Y.
Gardner, R. H., Grafton, Ohio
Garrison, H. D., Bell Tel. Laboratories, New York, N. Y.
Geisz, W. R., Mount Carroll, Ill.
Gerber, P. D., R. C. A. Victor Co., Inc., Camden, N. J.
Glimp, M. Z., Jr., Westinghouse Elec. & Mfg. Co., St. Louis, Mo.
Goetz, L. W., Wisconsin Telephone Co., Milwaukee, Wis.
Gray, E. T., Lincoln Power Co., Howe, Okla.
Green, I. L., Federal Telegraph Co., Palo Alto, Calif.

Grimm, C. J., Union Electric Lt. & Pr. Co., St. Louis, Mo.
Groch, F. R., Pacific Gas & Elec. Co., San Francisco, Calif.
Gurnham, R. G., Brown University, Providence, R. I.
Gussow, P. M., 914 First Court, Brooklyn, N. Y.
Gustafson, J. M., Commonwealth Edison Co., Chicago, Ill.
Hagmann, V., General Electric Co., Erie, Pa.
Hamilton, B. W., (Member) Montana Power Co., Great Falls, Montana
Hansford, E. M., General Electric Co., Schenectady, N. Y.
Hartwell, E. M., Electric Light Power & Railroad Co., Paul Smith's, New York
Hauser, H. T., City of San Francisco, Moccasin Power House, Moccasin, Calif.
Henschke, W. O., Westinghouse Elec. & Mfg. Co., Springfield, Mass.
Hill, G. L., Pacific Gas & Electric Co., Emerville, Calif.
Hollis, R. W., Jr., State of California, San Francisco, Calif.
Houston, C. E., Texas Technological College, Lubbock, Tex.
How, J. H., Stanford University, Stanford University, Calif.
Hubbard, W. N., The Bristol Co., Waterbury, Conn.
Hubbell, M. F., Emerson Electric Co., St. Louis, Mo.
Hulse, H. A., Jr., University of Colorado, Boulder, Colo.
Hutchinson, W. J. B., Bell Tel. Co. of Canada, Montreal, Que., Can.
Jablonski, J., Board of Education, Boys High School, Brooklyn, New York
Jagou, C. C., Westinghouse Electric International Co., Mexico, D. F., Mex.
James C. A., General Railway Signal Co., Rochester, N. Y.
Jochem, T. B., Marquette School of Engineering, Milwaukee, Wis.
Johnson, A. A., New York Edison Co., New York, N. Y.
Johnson, J. O., 26 Robinson Court, Burlington, Vt.
Johnson, R. L., New York Edison Co., New York, N. Y.
Jones, D. R., Philadelphia Electric Co., Philadelphia, Pa.
Karr, J. H., Purdue University, Lafayette, Ind.
Keeler, C. E., Yale Graduate School, New Haven, Conn.
Kelly, J. J., Fore River Shipbuilding Corp., Quincy, Mass.
Keltz, E. L., Wichita Cotton Oil Co., Electra Tex.
Kirwen, M. S., Allied Engineers, Inc., Muskegon, Mich.
Kober, W.,652 Southern Blvd., New York, N. Y.
Koehler, J. W., Can. General Electric Co., Ltd., Toronto, Ont., Can.
Krasnow, S., Jr., Bureau of Standards, Washington, D. C.
Kroitzsh, H., Suburban Gas & Electric Co., Revere, Mass.
Kuney, H. M., Goulds Pumps Inc., Seneca Falls, N. Y.
Lambert, W. H., Pennsylvania Electric Co., Johnstown, Pa.
LaPlante, R., Shawinigan Water & Power Co., Montreal, Que., Can.
Larose, V. A., Roland T. Oakes, Holyoke, Mass.
Lash, C. C., College of the Pacific, Stockton, Calif.
Lazo, N., New York Telephone Co., New York, N. Y.
Leeds, W. M., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Leiss, E. A., Radio Corp. of America, Harrison, N. J.
Lepone, R. G., R. C. A. Victor Co., Camden, N. J.
Levine, S. J., General Electric Co., Schenectady, N. J.
Lingary, J. W. (Member) Lynn Gas & Elec. Co., Lynn, Mass.
Little, G. R., University of Southern California, Los Angeles, Calif.
Locke, W. W., Jr., Worcester Polytechnic Institute, Worcester, Mass.
Malar, P. P., 188 Dundaff St., Carbondale, Pa.
Markow, A., New York Edison Co., New York, N. Y.
Marks, L. W., Johns Hopkins University, Baltimore, Md.
Martinoff, V. M., Hydro-Electric Power Comm. of Ont., Toronto, Ont., Can.
Matheson, D. R., Armour Institute of Technology, Chicago, Ill.
Matthews, G. D., Peoples Gas Light & Coke Co., Chicago, Ill.
Mayott, W. E., Brooklyn Edison Co., Brooklyn, N. Y.
McBride, A. W., General Development Co., Dallas, Tex.
McCauley, A. D., American Tel. & Tel. Co., Denver, Colo.
McConaghy, L. B., Ohio Edison Co., Akron, Ohio
McCurdy, J. D., Cutler-Hammer, Inc., Milwaukee, Wis.
McLennan, A. J., Mass. Institute of Technology, Cambridge, Mass.
Mendez, D. P., General Electric Co., Schenectady, N. Y.
Merriman, J. H., Northern States Power Co., Minneapolis, Minn.
Mesh, T. J., United Electric Light Co., Springfield, Mass.
Meyer, J. C., Allen Bradley Co., Milwaukee, Wis
Miller, V. W., Texas Electric Service Co., Fort Worth, Tex.
Molinaro, A. D., Philadelphia Electric Co., Philadelphia, Pa.
Moorhaus, A. C., Union Gas & Elec. Co., Cincinnati, Ohio
Morrison, R. L., Pamar's Radio Shop, Newberry, Pa.
Murtagh, T. P., New York Edison Co., New York, N. Y.
Nelson, R. A., John Brown Schools, Siloam Springs, Ark.
Nomann, A. B., R. F. D. 1, Whittier, Calif.
Oberwise, M. L., Allen-Bradley Co., Milwaukee, Wis.
O'Sullivan, R. G., Brooklyn Edison Co., Brooklyn, N. Y.
Park, C. P., 1114 Ashland Ave., River Forest, Ill.
Patel, R. M., Cornell University, Ithaca, N. Y.
Plomasen, C. G., Rochester Athenaeum & Mechanics Institute, Rochester, N. Y.
Plumb, C. E., General Electric S. A., Mexico, D. F., Mex.
Plymire, R. F., Puget Sound Pr. & Lt. Co., Seattle, Wash.
Potts, J. C., The Electric Storage Battery Co., Washington, D. C.
Preston, W. W., B. C. Electric Railway Co., Vancouver, B. C., Can.
Queen, W. H., United Air Lines, Chicago, Ill.
Quistorff, W., Puget Sound Pr. & Lt. Co., Seattle, Wash.
Reed, H. E., Maine Seaboard Paper Co., Bucksport, Me.
Reich, H. J., University of Illinois, Urbana, Ill.
Rieger, M., Jr., Western Electric Co., Kearny, N. J.
Roe, J. H., University of Minnesota, St. Paul, Minn.
Roland, S. W., University of Missouri, Columbia, Mo.
Rosenfeld, M., Union Switch & Signal Co., Swissvale, Pa.
Rowe, H. E., General Electric Co., Schenectady, N. Y.
Rucker, S. J., 465 Central Park West, New York, N. Y.
Sackman, G. W., Western Electric Co., Chicago, Ill.
Seielstad, H. D., Cadillac Motor Car Co., Detroit, Mich.
Shnaerof, H. L., Teleregister Corp., New York, N. Y.
Siebenmorgen, R. J., Electro Service Inc., Union City, N. J.
Silk, H., 123 Water St., Paterson, N. J.
Sinclair, A., Detroit Edison Co., Detroit, Mich.
Smith, F. D. (Member) United Lt. & Pr. Eng. & Const. Co., Davenport, Ia.

December 1931

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☐ **Annual Index for ELECTRICAL ENGINEERING V. 50, 1931**

Published separately in pamphlet form, one copy available upon request to each member or subscriber. The edition of this index will be governed by the number of requests received prior to January 15, 1932; printing and mailing will be deferred until after that date.

Snyder, L., Snyder Electric Shop, Glens Falls, N. Y.
Spittal, W. R., Ferranti, Inc., New York, N. Y.
Stadtfeld, N., Jr., United Elec. Lt. & Pr. Co., New York, N. Y.
Steele, E. S., Royal, Iowa
Steinbrenner, G., 1311 Pierce Ave., Niagara Falls, N. Y.
Stevens, C., Laddonia, Mo.
Stewart, W. E., Nebraska Wesleyan University, Lincoln, Nebr.
Stoddard, H. R., Simplex Wire & Cable Co., Cambridge, Mass.
Stortz, F. A., Jr., General Electric Co., Schenectady, N. Y.
Strawn, T. F., The Home Insurance Co., Quakertown, Pa.
Strommer, E. N., University of Pittsburgh, Pittsburgh, Pa.
Strupp, P. J., R. R. 2, Hartford, Wis.
Suhr, F. W., University of Minnesota, Minneapolis, Minn.
Sylvester, R. A., 417 South Center St., Pottsville, Pa.
Temple, H. P., Wagner Quarries Co., Sandusky, Ohio
Thurm, R. W., Engineering School of Milwaukee, Milwaukee, Wis.
Titter, B. K., Brooklyn Edison Co., Inc., Brooklyn, N. Y.
Troja, J. B., General Electric Co., Schenectady, N. Y.
Umlauf, A., General Electric Co., Schenectady, N. Y.
Vance, P. E., U. S. Engineer Office, Memphis, Tenn.
White, T. F. (Member) Texas Construction Co., Dallas, Tex.
Whitney, F. J., Jr., Lehigh University, Bethlehem, Pa.
Wilder, A. F., 36 Joy St., Boston, Mass.
Witt, F. L., Brooklyn Edison Co., Brooklyn, N. Y.
Wyman, K. S., U. S. Patent Office, Washington, D. C.
Young, F. E., Jr., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Younts, G. L., General Electric Co., Schenectady, N. Y.
Zilm, W. E., Drexel Institute, Philadelphia, Pa.
Zoercher, J. M., Indianapolis Pr. & Lt. Co., Indianapolis, Ind.
188 Domestic

Foreign

Chen, Y. C., Eastern Sales & Engineering Co., Tientsin, China
Kouyoumdjian, T., Lynch St., Bagdad, Irak
Mitchell, J. W. E., Public Works Dept., Shannon, N. Z.
NagaRajan, T. V., The Andrha Valley Power Supply Co., Ltd., Bhivpuri, Bombay Presidency, India
Tandon, P. L., Cantt. Board, Ambala, Punjab, India
Wadhera, C. L., c/o Lloyds Bank Ltd., New Delhi, India
6 Foreign

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Balaguer, Manuel M., c/o International Tel. & Tel. Co., 67 Broad St., New York, N. Y.
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Cater, C., Sandal, Church Road, Pinner, Eng.
Chilofsky, Joseph, 958 N. 7th St., Philadelphia, Pa.
Cordier, N. A., 126 Chatterton Pkwy., White Plains, N. Y.
Farnlof, Charles G. T., 1318 Laketon Road, Wilkinsburg, Pa.
Garrison, F. G., Internat'l Tel. & Tel. Corp., Buenos Aires, Arg., So. Amer.
Gaylord, R. H., 1814 Virginia Road, Los Angeles, Calif.
Goldsman, Jacob L., 64 Priory Rd., Hampstead, London, Eng.
Kamm, J. Lloyd, 1801 N. Lamar St., Dallas, Texas.
McCulloch, G. B., McVie Caterers, Ltd., Sydney, N. S. W., Australia.
Melson, Sydney W., Yeatton Woolrich Road, Abbey Wood, London, S. E. 2, England.
Mountain, C. E., Burma Elec. Supply Co., Mandalay, Burma, India.
Parr, J. C., 245 - 71st Street, Brooklyn, N. Y.
Pernick, A. S., Westinghouse High Voltage Lab., Trafford, Pa.
Pierson, Walter D., 4710 Locust St., Philadelphia, Pa.
Pistorius, L. H., 193 Jeppe St., Johannesburg, South Africa.
Schrock, John E., 3720 Main St., Lawrence Park, Erie, Pa.
Stempfle, Frederick, 8126 E. Vernor Highway, Detroit, Mich.
Tate, William, Apartado No. 41, Publa, Mexico.
Thakkur, K. B., Box 654, Whiting, Ind.
Voronovsky, T. G., 1162 Waverly Place, Schenectady, N. Y.

Engineering Literature

New Books

In the Societies Library

Among the new books received at the Engineering Societies Library, New York, during October are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

WHO'S WHO IN ENGINEERING. Edited by W. S. Downs and M. M. Lewis. 3rd ed., 1931. N. Y., Lewis Historical Publ. Co. 1536 pp., 10 x 6 in., cloth, $10.00.——The third edition of this useful work of reference is restricted, in accordance with the recommendations of the advisory committee appointed by the American Engineering Council, to living American engineers who have been practising or teaching engineering for at least ten years. About ten thousand names are included, with authentic brief information regarding professional experience, publications, education, addresses, etc. A geographic index is given.

GEOLOGIC INDEX OF THE PUBLICATIONS OF THE UNITED STATES GEOLOGICAL SURVEY. By G. H. Albertson. Denver, Col., Geological Publ. Co., 1931. 420 pp., 10 x 7 in., leather, $10.00.——Geologists and engineers who have occasion to consult the publications of the United States Geological Survey owe a debt of gratitude to the compiler of this index. It covers all the publications of the Survey and is classified by the latitude and longitude of each locality, the unit being a thirty-minute quadrangle. Key maps make it easy to locate the desired entry, where all the references to the locality will be found.

STARS IN THEIR COURSES. By J. Jeans. N. Y., Macmillan Co.; Cambridge, England, University Press, 1931. 173 pp., illus., diagrs., charts, tables, 8 x 5 in., cloth, $2.50.——This work, based upon a series of radio talks, is a delightful introduction to modern astronomy written in an informal conversational style by a great astronomer. Starting with a general account of the heavens, the sun's family, the stars, the milky way and the universe as a whole are discussed. Two star maps and a description make possible the identification of the constellations. The book is ideal for the general reader.

1931 SUPPLEMENT TO BOOK OF A.S.T.M. STANDARDS. Philadelphia, American Society for Testing Materials, 1931. 144 pp., 9 x 6 in., paper, $1.50.——This supplement brings up to date the 1930 Book of Standards published by the Association. It contains thirty-two standards, seventeen of which are new and fifteen replacements of former ones. Among them are specifications for alloy-steel, bolting material for high-temperature service; welded wrought-iron pipe; high-test gray-iron castings; aluminum-alloy sheets and castings; hydrated lime; structural clay tile; white and red lead; and bronze powders. Methods are given for testing concrete, brick, pigments, slate, insulating oils, and other materials.

ALTERNATING-CURRENT CIRCUITS. By J. M. Bryant and J. A. Correll. 2nd ed. N. Y., McGraw-Hill Book Co., 1931. 492 pp., diagrs., charts, tables, 9 x 6 in., cloth, $4.50.——An introductory course in the study of a-c. circuits and transmission lines, based upon that given at the University of Texas. The theory of alternating currents first is discussed, and the equations that apply to the various types of circuits developed from the fundamental physical and mathematical principles. In the latter part of the book these principles are applied to polyphase circuits and transmission lines. This edition has been revised, and a new chapter on the consideration of unbalanced polyphase circuits by means of symmetrical phase components has been added.

ELECTROCHEMISTRY. By C. J. Brockman. N. Y., D. Van Nostrand Co., 1931. 348 pp., illus., diagrs., charts, tables, 9 x 6 in., cloth, $4.00.——This book aims to point out the more important applications of the electrical current in chemical manufactures, in a manner that will interest chemists, manufacturers, and plant managers. The general principles are followed by descriptions of the electrometallurgy of the industrial metals, the production of gases and of electrothermal processes. References to sources are numerous.

FRACTIONAL HORSE POWER MOTORS. By A. H. Avery. Lond. & N. Y., Isaac Pitman & Sons, 1931. 152 pp., illus., diagrs., charts, tables, 8 x 5 in., cloth, 7s 6d; $2.25.——The essential features of motors with power outputs of less than ½ hp. are presented concisely. Design, constructional features, commutaton and insulation are discussed. Testing and repairing are considered also.

INDUSTRIAL ELECTROCHEMISTRY. By C. L. Mantell. N. Y., McGraw-Hill Book Co., 1931. 528 pp., illus., diagrs., charts, tables, 9 x 6 in., cloth, $5.00.——Intended both as a textbook in chemical engineering courses and as a work of reference, this book is written from the engineering point of view and stresses the practical aspects of electrochemical processes. Introductory sections on theoretical and technical electrochemistry are followed by sections on electrolytics, electrothermics, and the electrochemistry of gases, in which the industrial uses for winning, plating, refining and melting metals, for manufacturing gases and chemicals, etc., are described. A final section, engineering, discusses materials and power generation.

MESSENTLADUNGSSTRECKEN (Ionenstrecken). By S. Franck. Berlin, J. Springer, 1931. 192 pp., illus., diagrs., charts, tables, 9 x 6 in., cloth, 18.50 RM. unbound; 19.50 RM. bound.——This monograph aims to describe the uses of self-maintaining electrical discharges through gases for purposes of measurement and to give exact particulars of the various methods. The widely scattered literature is reviewed quite thoroughly, and full references are given to the original papers. The theory of discharges through gases is presented very briefly, as an introduction to the methods of measurement.

MONOGRAPHS ON PHYSICAL SUBJECTS. N. Y., E. P. Dutton & Co., 1931. Diagrs., charts, tables, 7 x 4 in., cloth, $1.10 each.——(1) Commutator Motor. By F. J. Teago. 80 p. (2) Photochemistry. By D. W. G. Style. 96 p. (3) Thermodyanmics. By A. W. Porter. 96 p. These concise little volumes by men actively engaged in research work on the subjects about which they write, are intended to supply readers of average scientific attainments with compact statements of the modern position in each subject. They are admirably adapted to the needs of those not in contact with active scientific work or engaged on work in related sciences who wish to become quickly conversant with the accepted principles in various fields.

Selected Items From Engineering Index Service

SELECTED references to current electrical engineering articles from Engineering Index Service's review of some 2,000 technical periodicals are given in the following columns.

All articles indexed are on file in the Engineering Societies Library, New York, which will furnish photoprints of any article at a cost of 25 cents per page or make translations of foreign articles at cost.

Armatures

MEASUREMENTS. An Electrical Method for Determining the Moment of Inertia of a Direct-Current Armature, J. C. Prescott. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 417, Sept. 1931, pp. 1179-1183, 3 figs. Method of determination described requires for its application d-c. quantity meter in addition to voltmeter and ammeter used in method described by G. Kapp; theory and application of this "quantity meter" method are investigated and experimental results are cited to show degree of accuracy that can be obtained.

Cables

LEAD SHEATHING. Lead Covered Cable. *Wire*, vol. 6, no. 10, Oct. 1931, pp. 402-404, 5 figs. Types and uses of lead cable as compiled by Lead Assn.; cable using lead covering; cable sheath metal; telephone cables; power cable; voltages.

SUBMARINE—PROTECTION. Protective Cable Anchoring. *Elec. Rev.*, vol. 109, no. 2802, Aug. 7, 1931, pp. 209-210, 6 figs. Instance of submarine power cables withstanding ship's dragging anchor.

TELEPHONE. British Columbia 1931 Telephone Cable, M. C. Timms. *Telephony*, vol. 101, no. 13, Sept. 26, 1931, pp. 30 and 32, 4 figs. Gutta-percha insulated submarine telephone cable laid by British Columbia Telephone Co., between Mainland and Vancouver Island, Can.; construction identical to that of ocean cables; manufacturing methods.

Condensers

MEASUREMENT. Measurement of Small Capacities, V. V. Sathe and T. S. Rangachari. *Wireless Engr.*, vol. 8, no. 97, Oct. 1931, pp. 543-547, 7 figs. Compact and self-contained d-c. tubes operated arrangement working on principle of substitution is described for measuring capacities from .002 microfarad down to minute capacities such as inter-electrode capacities of tubes.

Conductivity

On the Resistance of Lead to High-Frequency Currents at Superconducting Temperatures, J. C. McLennan, A. C. Burton, A. Pitt, and J. O. Wilhelm. *Lond., Edinburgh and Dublin Philosophical Mag. and Jl. Science*, vol. 12, no. 78, Sept. 1931, pp. 707-719, 5 figs. Attempts to find changes in behavior of lead paralleling that of superconductivity for very high frequencies of light waves; in designing experiment highest frequency amenable to accurate measurements, *i. e.*, 10,000 kc. per sec. was chosen; with currents of this frequency phenomenon of superconductivity might occur at lower temperature than 7.2 deg. K., might be only partial, or might not appear at all.

Conduits

CONSTRUCTION. Conduit and Manhole Construction. *Elec. News*, vol. 40, no. 18, Sept. 15, 1931, pp. 41-44, 6 figs. Bell forms of conduit simplify duct-mouth construction; transit-mixed concrete for congested areas; separate trunk line transmission conduit systems where feasible; driven service pipes for customer connections; manholes should not be less than 6 ft. in height; street loading and roof strength precautions; shapes to conform to requirements; precast service boxes; transformer vaults under sidewalk; roof construction; covers and castings; ventilation.

Converters

FREQUENCY. Frequency Changers Also Have Stability Limits, T. G. LeClair and A. J. Krupy. *Elec. World*, vol. 98, no. 13, Sept. 26, 1931, pp. 558-561, 6 figs. Operating conditions indicated that synchronous tie between 25- and 60-cycle systems of Commonwealth Edison Co. might not remain stable under certain disturbances; tie consists only of two 40,000-kw. synchronous frequency changers; tests demonstrate that with both machines under full load loss of one under fault would cause loss of synchronism between systems, although sudden removal of one machine without fault did not.

Corrosion

UNDERGROUND STEEL. The Electrolytic Corrosion of Underground Metallic Structures by Stray Currents, C. M. Longfield. *Instn. Engrs. Australia—Jl.*, vol. 3, no. 8, Aug. 1931, pp. 283-285. Discussion of paper previously indexed from issue of May 1931.

Currents

ALTERNATING—TEXTBOOK. Alternating Currents, C. E. Magnusson. 4th edit., N. Y., McGraw-Hill Book Co., 1931, 685 pp., illus., diagrs., charts, tables, $5.00. Textbook for undergraduate students which discusses fundamental principles of subject and shows their application to industrial problems; changes in edition include rewriting and extension of chapter on instruments, new chapters on systems of units and symbols, on mercury-arc rectifiers and on hot-cathode rectifiers and oscillators, as well as many new diagrams and illustrations. Eng. Soc. Lib., N. Y.

Education

Study of Technical Institutes. *Jl. Eng. Education—Supp.*, vol. 22, no. 1, Sept. 1931, 39 pp., 7 figs. Summary report intended to present in small compass principal findings, conclusions and data of study for wide distribution; contents of bulletin divided into two parts; principal findings and conclusions, and summary of data.

UNITED STATES. Engineering Educational Standards, L. W. Wallace. *Agric. Eng.*, vol. 12, no. 9, Sept. 1931, pp. 343-345, 1 fig. Comments on Dr. W. E. Wickenden's report to Society for Promotion of Engineering Education; each institution should make thorough study of territory it serves and should major on problems peculiar to its area; need for greater standardization of research programs; engineering teachers should be systematically taught how to teach; engineering profession foundation needs to be broadened in direction of social and cultural graces. Before Am. Soc. Agric. Engrs.

Electric Drive

AUTOMOBILE PLANTS. Ford Substitutes A-C. Motors for 27,000 D-C. Units. *Elec. World*, vol. 98, no. 11, Sept. 12, 1931, pp. 452-455, 8 figs. Methods of changing 85,000 hp. in River Rouge plant to alternating from d-c. drives; benefits include conspicuous reduction to maintenance costs and large decrease of energy lost in plant distribution; studies of drive duties reveal opportunities for scaling down motor sizes.

CEMENT KILNS. Methods of Foolproof Control in Cement Works, S. Hopferwieser. *Brown Boveri Rev.*, vol. 18, no. 9, Sept. 1931, pp. 279-287, 18 figs. Complete diagram of connections for electric operation of rotary kiln plant; diagram of electric interlocking connections between drive of rotary kiln and corresponding cooling drum; diagram of connections for remote controlled three-phase double commutator motor of 130 kw.; 1,000-500 r.p.m. driving rotary kiln fan; electrical operation of Lepol rotary kiln plant.

GRINDING MACHINES. Motorization of Modern Grinders, J. W. Harper. *Iron Age*, vol. 128, no. 16, Oct. 15, 1931, pp. 988-991 and 1020-1021, 6 figs. Methods of mounting electric motors on different types of grinding machines; bench and floor-type machines; time ratings of grinder motors; chart showing relation of wheel speed to peripheral speed for grinding wheels of various sizes; high frequencies for high speeds.

Electric Power

ICE PLANTS. Unit Data on Distilled-Water Ice Plant, R. H. Parrish. *Elec. World*, vol. 98, no. 11, Sept. 12, 1931, p. 461. Twelve months' observed data on tons output and kilowatt-hour input on typical South Texas distilled water ice plant with capacity of 90 tons per 24 hr., using can system, may be of value to other similar sized plants as means of comparison.

INDUSTRIAL PLANTS. Industrial Electrification—III, R. H. Silmot. *Elecn.*, vol. 107, no. 2779, Sept. 4, 1931, pp. 304-306, 3 figs. Group drive *versus* individual drive; types and selection of motors; motor driven.

Load Control in Industrial Plants, R. R. Ruggles. *Power Plant Eng.*, vol. 35, no. 18, Sept. 15, 1931, pp. 935-937, 4 figs. Advantageous application of load regulation illustrated by hypothetical case of industrial plant with fluctuating load which purchases power from large central station but also equipped to generate certain portion of its total load requirements; typical wiring diagram of automatic load regulator working on prime mover.

Electric Equipment

EXHIBITIONS. Electrical Machinery and Instrument Design in the Nineteenth Century. *World Power*, vol. 16, no. 93, Sept. 1931, pp. 177-194, 10 figs. Chronological order of exhibits organized by British Electrical & Allied Manufacturers' Assn.; article divided into three parts: Part I dealing with history of development of electricity generator from Pixii's machine in 1831 up to d-c. machines constructed by Crompton, Brush, and between 1880 and 1890 and Ferranti alternator of 1882; Part II describes Instrument Section, and Part III gives brief description of power station model.

OPERATION. Practises That Improve the Operation of Electrical Equipment. *Power*, vol. 74, no. 8, Aug. 25, 1931, pp. 282-284, 4 figs. Modern operating practises that have been adopted to meet requirements for higher degree of reliability and demands for more exact knowledge of equipment performance.

Electrolytes

PUMPS. A Circulating Pump for Liquids, D. R. Barber. *Jl. Sci. Instruments*, vol. 8, no. 6, June 1931, pp. 183-188, 3 figs. Description of non-metal pump designed primarily for circulation of electrolytes; performance of apparatus is discussed from theoretical standpoint, and typical calibration curves obtained with experimental pump are given.

Elevators

ELECTRIC—SIGNAL SYSTEMS. Pre-Register Signal System Stops Elevators Automatically. *Power*, vol. 74, no. 11, Sept. 15, 1931, pp. 391-393, 5 figs. System in which signals to stop are registered in advance by buttons in car and from landings; at proper point in car's travel operator notified by signal to center car switch so that car will stop automatically at landing for which signal was given; equipment design and operation.

OFFICE BUILDINGS. Planning Elevators for Special Service, C. F. Scott. *Eng. News-Rec.*, vol. 107, no. 15, Oct. 8, 1931, pp. 569-571, 6 figs. Description of vertical transportation system of new McGraw-Hill building in New York; nine passenger cars are all 3,500 lb. capacity, in size 7 ft. 4 in. by 6 ft. 4 in., with openings 3 ft. 8 in. wide; high rise cars, running at 800 ft. per min., are equipped with automatic control; low-rise passenger cars, running at 600 ft. per min., are equipped for manual operation, with automatic leveling; smooth operation is obtained through perfected control and extra heavy guide rails; details of pliotron floor leveling mechanism.

Engineering Writing

Technical Writing, T. A. Rickard. 3rd edit., N. Y., John Wiley & Sons, 1931, 337 pp., $2.00. Interest in correct speech has become much more wide-spread since author's book first appeared in 1919, and many textbooks have appeared since that date; his work still remains, however, one of most readable and best guides to engineer who wishes to improve his power of expression; new edition, prepared for American Institute of Mining and Metallurgical Engineers, differs from second edition only in sundry small corrections. Eng. Soc. Lib., N. Y.

Engineers

UNITED STATES. Who's Who in Engineering, edited by W. S. Downs and M. M. Lewis. 3rd edit., 1931, N. Y., Lewis Historical

Publ. Co., 1536 pp., $10.00. Edition is restricted, in accordance with recommendations of advisory committee appointed by American Engineering Council, to living American engineers who have been practising or teaching engineering for at least 10 years; about 10,000 names are included, with authentic brief information regarding professional experience, publications, education, addresses, etc.; geographic index is given. Eng. Soc. Lib., N. Y.

Furnaces

ANNEALING. Annealing and Cleaning Strip Steel for Cold-Rolling. *Iron Age*, vol. 128, no. 16, Oct. 15, 1931, pp. 1000-1003, 4 figs. Layout and operation of electric furnaces at Cuyahoga works of American Steel & Wire Co.; 24 bell type furnaces of 90- to 100-kw. capacity each; operated on three-phase, 220-volt, 60-cycle current; artificial atmosphere; continuous cleaner with various new features in connection with take-up frame.

FOUNDRY. Electric Furnace Developments in Foundries, A. E. Greene. *West Machy. World*, vol. 22, no. 9, Sept. 1931, pp. 424-427, 5 figs. Change from crucible melting furnace to electric furnace; typical furnace installations for economical production of steel and cast iron.

GASES. Principles and Some Practical Applications of Electric Furnaces with Atmospheric Control, A. N. Otis. *Iron and Steel Engr.*, vol. 8, no. 8, Aug. 1931, pp. 352-359 and (discussion) 359, 14 figs. Apparatus for reforming hydrocarbon gases, such as butane, illuminating gas or natural gas into gas consisting largely of free hydrogen, for dissociating ammonia into hydrogen and nitrogen; cost of gases by various methods of procurement; dissociation pressure in atmospheres for iron oxide; hood furnaces for bright-annealing; elevator type furnaces; tunnel type counterflow furnace for heating and cooling in atmosphere of electrolene. Before Am. Iron and Steel Elec. Engrs.

Fuses

The Pressures Produced on Blowing Electric Fuse Links: The Effect of the Surrounding Atmosphere, G. Allsop and P. B. Smith. *Safety in Mines Research Board—Paper*, no. 67, 1931, 19 pp., 1 fig. Fuse links of tinned copper wire have been blown by currents ranging from minimum fusing current to medium overload current at 200 volts d-c. in closed rectangular vessel of 54.0 cu. in. capacity; vessel was thermally and electrically insulated evacuated and filled with gas at known pressure; gases used were: air, oxygen, nitrogen, hydrogen, chlorine, carbon dioxide and argon under atmospheric and other pressures; oscillograms and pressure records were taken during each experiment.

Generators

ALTERNATING CURRENT. Armature Reaction in Salient-Pole Alternators, W. H. Ingram. *Lond., Edinburgh and Dublin Philosophical Mag. and Jl. Science*, vol. 12, no. 78, Sept. 1931, pp. 690-707, 11 figs. Theory of alternator as self-modulating dynamical system is outlined; fundamental in it is a family of field magnetomotive and electromotive force characteristics, of which rotor position coordinate is parameter.

WATERWHEEL. Umbrella-Type Generators Reduce Hydro Plant Costs, H. B. Crandall. *Power*, vol. 74, no. 10, Sept. 8, 1931, pp. 358-359, 4 figs. Construction of umbrella-type slow-speed vertical-shaft waterwheel generator and space requirements; comparison with machines of usual design; advantages and disadvantages of various designs of waterwheel generators.

Heating

BUILDINGS. The Electrical Heating of Buildings, R. Grierson. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 417, Sept. 1931, pp. 1045-1090 and (discussion) 1091-1116, 21 figs. Types of electric warming equipment; general details and considerations, *i. e.*, measurement of comfort, physiological, hygienic, architectural and decorative aspect; ventilation; high-temperature *vs.* low-temperature radiating surfaces; continuous *vs.* intermittent heating, etc.; information as actual installations, etc., and bibliography given in 11 appendixes.

RAILROAD BUILDINGS. Reading Installs Thermal-Storage Electric Heating System. *Ry. Elec. Engr*, vol. 22, no. 9, Sept. 1931, pp. 239-240, 2 figs. Unique heating plant used in power dispatcher's building on electrified territory at Philadelphia.

Hydroelectric

PUMPED STORAGE. Waeggital Pumped-Storage Hydro-Electric Scheme. *Engineering*, vol. 132, no. 3425, Sept. 4, 1931, pp. 292-294, 4 figs. Power scheme near Zurich has annual output of 110,000 kw-hr. generated in two stations mainly during winter months; dam closing gorge is of solid gravity type, 363 ft. high by 515 ft. long; pressure tunnel of circular cross-section and 12-ft. internal diam. is capable of carrying 1,160 cu. ft. of water per sec.; Rempen power station has four vertical-shaft Francis-type spiral turbines, each with output of 22,500 hp. at speed of 500 r.p.m.; Siebnen station contains four turbines of same type with outputs of 14,750 to 17,500 hp. at 500 r.p.m.

Insulation

BUILDINGS. Control of Heat, Light and Sound in Modern Buildings, E. C. Rack. *Heat., Piping and Air Conditioning*, vol. 3, no. 9, Sept. 1931, pp. 734-740, 6 figs. Use of insulation for controlling heat, light and sound in modern plants and buildings has developed rapidly within past few years; practical discussion of utilization of insulation of modern buildings; economical thickness of insulation; research and materials for future.

Insulating Materials

STRENGTH. System Insulation Strengths, S. A. Stigant. *Elec. Rev.*, vol. 109, no. 2808, Sept. 18, 1931, pp. 425-426, 5 figs. Introduction to study of coordination of insulation strengths of electrical transmission systems.

Insulators

SUPPORTS. Simpler Supports for Pin Type Insulators. *Elec. Times*, vol. 80, no. 2082, Sept. 17, 1931, p. 431, 2 figs. Eradication of inherent disabilities of existing forms of pole top equipment is aimed at in new tubular system described below.

Lamps

GLOW—VOLTAGE. New Low Voltage for Tube Lighting, E. Clute. *Am. Arch.*, vol. 140, no. 2600, Oct. 1931, pp. 42, 64 and 66, 6 figs. Revolutionary improvements in production of light by glass tubes filled with rare gases have made it adaptable to architect's requirements as never before; most important of all is recent practical development of low voltage tubes; some of applications and possibilities illustrated.

INCANDESCENT—BURN-OUTS. Calculating Lamp Burn-Out, H. H. Webb. *Elec. World*, vol. 98, no. 12, Sept. 19, 1931, p. 505, 1 fig. Simple formula for calculating normal rate of burn-out of lamps.

ULTRA-VIOLET. The Problem of the Definition and Measurement of the Useful Radiation of Ultra-violet Lamps, C. H. Sharp and W. F. Little. *Illum. Eng. Soc.—Trans.*, vol. 26, no. 7, Sept. 1931, pp. 727-737 and (discussion) 737-743, 2 figs. Most of methods for measuring on basis of erythemal effect are approximate in character and in generality of cases do not give sufficiently comparable results; need for coordination in this field of measurement is pointed out and for establishment of standards both in form of standard methods and physical standards of erythemal radiation; second part reviews most commonly employed physical methods of measurement.

Light and Lighting

Visual Efficiency in Quiet and Noisy Workplaces, M. Luckiesh. *Elec. World*, vol. 98, no. 11, Sept. 12, 1931, pp. 472-473. Results of experiment in which rate of performing exacting visual work was measured in quiet room and in room in which several 10-kw. motor-generator sets were operated.

ULTRA-VIOLET. Industrial Uses of Ultra-violet, E. E. Free and C. C. Clark. *Illum. Eng. Soc.—Trans.*, vol. 26, no. 7, Sept. 1931, pp. 744-755. Summary of industrial applications of ultra-violet under five main headings, each of which is discussed in detail with respect to previous accomplishments and probable future use; need of some simple, reliable means of measuring ultra-violet is stressed and plea made for sources of ultra-violet radiation more intense and more nearly monochromatic than those now available.

STREET. The Street Lighting Requirements of Different Types of Street, J. F. Colquhoun and W. S. Stiles. *Surveyor*, vol. 80, no. 2068, Sept. 11, 1931, pp. 255-256. Requirements which must be considered in lighting different types of streets: revealing power, attractiveness by night, attractiveness by day; dependence of these requirements on brightness level, diversity characteristics of source, etc.; disability and discomfort glare; spectacular lighting. Before Int. Illum. Congress.

Loud Speakers

DESIGN. Dynamic Loudspeaker Design—II, J. E. Goeth. *Electronics*, vol. 3, no. 3, Sept. 1931, pp. 112-113 and 130, 3 figs. Actual computation for typical case is given; data calculated are compiled in table form.

Magnetism

Influence of Hydrostatic Pressure on the Critical Temperature of Magnetization for Iron and Other Materials, L. H. Adams and J. W. Green. *Terrestrial Magnetism and Atmospheric Electricity*, vol. 36, no. 3, Sept. 1931, pp. 161-169, 5 figs. Tests in order to determine whether or not temperature at which iron and other ferromagnetic substances pass from magnetic to non-magnetic state is affected by increase of pressure; specimens of materials investigated were made up as core of miniature transformer or induction-unit, and placed in electrically heated pressure-bomb; six-volt alternating-current was supplied.

Manometers

IONIZATION. A New Design of an Ionization Manometer, E. K. Jaycox and H. W. Weinhart. *Rev. Sci. Instruments*, vol. 2, no. 7, July 1931, pp. 401-411, 11 figs. Vacuum gage described has been developed for measuring pressure of residual gas in highly exhausted experimental tubes used in study of thermionic and photoelectric phenomena at pressures of order of 0.00000001 mm. mercury or lower.

Measurements

A Resistor for the Measurement of Large Direct Currents, E. H. Rayner. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 417, Sept. 1931, pp. 1155-1159, 2 figs. Serious uncertainties in effective value of low resistances for measurement of large currents may be caused by variations of current distribution at their terminals; temperature-rise is also important cause of variation; application of principles for reduction of these errors has been basis of design of resistor of 20 microhms, which has been found satisfactory as reference standard for measurement of currents up to 25,000 amperes.

Metering

REMOTE. Remote Metering System Calibrated Quickly, U. Davis. *Elec. World*, vol. 98, no. 11, Sept. 12, 1931, p. 458, 1 fig. Impulse remote metering system instruments can be checked from load dispatcher's office of Commonwealth Edison Co.; diagram showing 25-cycle part of system.

Microphones

CALIBRATION. The Calibration of Microphones, H. F. Olson and S. Goldman. *Electronics*, vol. 3, no. 3, Sept. 1931, pp. 106-108 and 130, 8 figs. Methods for calibrating various types of microphones including Rayleigh disk, actuator method and thermophone method; comparative curves are given for different microphones.

Motors

BRAKING. Dynamic Braking *versus* Plugging as a Means of Accurate Stopping, P. McShane. *Elec. Jl.*, vol. 28, no. 9, Sept. 1931, pp. 516-517, 4 figs. When accurate stopping is essential function of motor application, shunt-wound motor, because of its characteristics, is generally used; two methods are used to bring motor to stop, dynamic braking and plugging; simple discussion of both methods, their applications and advantages.

INDUCTION—CIRCLE DIAGRAM. The Circle Diagram of the Polyphase Induction Motor, C. C. Hawkins. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 417, Sept. 1931, pp. 1149-1154, 3 figs. Values of radius and coordinates of center of circle diagram of polyphase induction motor are determined algebraically in form covering not only ordinarily accepted equivalent network, but also more accurate equivalent network in which iron losses for stator and rotor are represented separately.

STARTING. A Combined Motor Starting and Power Factor Correcting Panel. *Engineer*, vol. 152, no. 3948, Sept. 11, 1931, pp. 276-277, 1 fig. Electrical Construction Co. has introduced motor-starting panel, in which all necessary gear for starting, protecting and improving power factor of squirrel-cage machine is contained.

SYNCHRONOUS. Emergency Full-Voltage Starting of Synchronous Motors, C. C. Nelson. *Power*, vol. 24, no. 11, Sept. 15, 1931, p. 399. Automatic emergency full-voltage starting accomplished by balanced-frequency relay; practical discussion of operating features.

Fans Cool Totally Inclosed Synchronous Motors, C. C. Shutt. *Power*, vol. 74, no. 11, Sept. 15, 1931, pp. 396-397, 4 figs. Synchronous motors of 250-hp. rating have been built that are totally inclosed and cooled by external and internal fans for use in severe atmospheric conditions and to operate at 5,000-ft. altitude; motor design and construction.

SYNCHRONOUS—BRAKING. Synchronous Motors Stopped in Three Revolutions, A. S. Rufsvold. *Elec. World*, vol. 98, no. 13, Sept. 26, 1931, pp. 556-557, 2 figs. 400 hp. motor stopped from 450 r.p.m. to rest in 1.25 sec. by allowing armature current only half inrush value at starting; this meets emergency stop conditions, eliminates coasting time of heavy equipment and is applicable to bandsaws, rolls and intermittent operations.

Networks

INTERCONNECTED. The Economic Value of Major System Interconnections, N. E. Funk. *Jl. Franklin Inst.*, vol. 212, no. 2, Aug. 1931, pp. 171-208, 24 figs. Table of power input, loss and delivery of 20 sections, 1,000-mile transmission line; why interconnections between power systems are desirable; details of 220-kv. interconnection of Pennsylvania Power & Light Co., Public Service Electric & Gas Co., and Philadelphia Electric Co.; details are given.

PROTECTION. Protecting A Medium-Voltage Network, J. S. Parsons. *Elec. Jl.*, vol. 28, no. 9, Sept. 1931, pp. 520-525, 5 figs. Proper operation of primary a-c. network depends upon satisfactory protective system; plan outlined makes possible adequate relaying, using only well-known and dependable equipment.

Oscillographs

CATHODE-RAY. A Method of Obtaining a Linear Time Axis for a Cathode Ray Oscillograph, A. L. Samuel. *Rev. Sci. Instruments*, vol. 2, no. 9, Sept. 1931, pp. 532-540, 5 figs. Usefulness of cathode-ray oscillograph tube of type of Western Electric no. 224-B is enhanced by any circuit that will provide linear time axis; one method used in Bell Telephone Laboratories employs hot-cathode three-element gas-filled tube in usual "sweep" circuit; this method possesses advantages in reproducibility, ease of control and synchronization; brief description of tube is given together with simple analysis of behavior of circuit. Bibliography.

Photoelectric

CALCULATING MACHINES. A Photoelectric Integraph, T. S. Gray. *Jl. Franklin Inst.*, vol. 212, no. 1, July 1931, pp. 77-102, 12 figs. Machine for purpose of facilitating mathematical solution of problems requiring evaluation of integral in which integrand involves variable parameter is described in this article; it involves use of optical system in which transmission of light is limited in definite manner by apertures having shape of area under curves representing mathematical functions; accuracy of machine itself is from 2 to 5 per cent.

Photoelectric Cells

Photocell Theory and Practise, V. K. Zworykin. *Jl. Franklin Inst.*, vol. 212, no. 1, July 1931, pp. 1-42, 33 figs. Methods of preparation of cell; application in motion pictures television. Simplicity Extends Light-Control Possibilities. *Radio Eng.*, vol. 11, no. 9, Sept. 1931, pp. 21-22, 3 figs.; see also *Radio Industries*, vol. 6, no. 5, Sept. 1931, pp. 166-167, 3 figs. Burgess Radiovisor Bridge new light sensitive cell and simplified associated apparatus, introduced to engineers and experimenters.

COLORIMETRY. The Applicability of Photoelectric Cells to Colorimetry, H. E. Ives and E. F. Kingsbury. *Optical Soc. Am.—Jl.*, vol. 21, no. 9, Sept. 1931, pp. 541-563, 18 figs. Critical consideration of requirements for precision physical colorimeter, and estimation in light of experimental data on new types of photoelectric cells, as to what degree requirements for physical colorimetry may be met at present time; paper is very specially limited to problems of precision color measurement.

Photometers

DAYLIGHT. A Daylight Factor Integrator, H. C. H. Townend. *Jl. Sci. Instruments*, vol. 8, no. 6, June 1931, pp. 177-183; 5 figs. Instrument determines mechanically illumination at point on horizontal surface due to direct light from sky visible at that point; instrument is set up at point, and telescope incorporated in it is made to traverse boundary of visible sky; daylight factor is read off from small integrating wheel.

Photometry

A Method of Measuring the Integrated Light from Short Flashes of High Intensity, L. R. Koller. *Rev. Sci. Instruments*, vol. 2, no. 9, Sept. 1931, pp. 551-553, 1 fig. In course of some tests of flashing beacons for airports it was necessary to measure integrated light from flashes of high intensity but of very short duration; for this purpose circuit using photoelectric tube and thyratron was developed by means of which measurements could be made with great ease to within accuracy of about 10 per cent.

Power Industry

GOVERNMENT CONTROL. Governor Takes Firm Stand Against Government Ownership, A. C. Ritchie. *Elec. World*, vol. 98, no. 13, Sept. 26, 1931, pp. 540-542. Government ownership of power industry would make us political slaves of federal government; state regulation suitably strengthened where it is lacking will solve all problems better than any form of state ownership. Before Am. Bar Assn.

Power Plants

ELECTRIC DRIVE. Large and Small Motors in the Modern Industrial Steam Power Plant, E. A. Murray. *Eng. and Finance*, vol. 25, nos. 2 and 3, Aug. 1931, pp. 29-30 and 38, and Sept., pp. 48 and 57. Specific applications boiler feed pump; circulating pumps; hot-well pumps; forced and induced draft fans; stokers; pulverized coal feeders; pulverizer mills; clinker grinders.

NATURAL GAS. The World's Largest Industrial Consumer, R. M. Bauer. *West. Gas*, vol. 7, no. 5, May 1931, pp. 42-44 and 100, 6 figs. Description of Southern California Edison Co.'s Long Beach steam plant which burns natural gas in huge quantities to supply light and power needs of Southern California; article is non-technical in treatment, laying particular stress upon burner design and gas usage.

Radio

AIRPLANES. Radio on Dutch Air Lines Insures Safety, L. Bruchiss. *Radio Industries*, vol. 6, no. 5, Sept. 1931, pp. 168-169, 4 figs. As example of foreign radio in aircraft, air routes of K. L. M., Royal Dutch Air Lines are taken; began operations in 1920, and may be considered as hub of continental air traffic; since establishment of 10,000 mi. Holland-Dutch East India line, longest mail and passenger route in existence at present, K. L. M. radio equipped airplanes touch three continents; equipment is illustrated and described.

AMPLIFIERS. Tube Amplifier Equivalent Parallel Circuit, G. D. Robinson. *Electronics*, vol. 3, no. 3, Sept. 1931, p. 105, 1 fig. It is shown that parallel substitution for simple series circuit is merely simplification of general parallel equivalent circuit, in which internal plate resistance, load, and grid-to-plate reactance are all treated as being in parallel.

CONTROLS. An Analysis of the Series Type Mixing Control, L. B. Halliman, Jr. *Radio Eng.*, vol. 11, no. 9, Sept. 1931, pp. 17-18, and 35, 8 figs. Discussion of various control systems and faders for use in radio broadcasting, talking motion picture and phonograph recording work, when using more than one microphone to obtain more natural and higher quality of reproduction or to have level from each microphone under absolute control and to have each control independent of other.

OSCILLATORS. Quartz Oscillator Wave Constants, E. G. Watts. *Radio Eng.*, vol. 11, no. 9, Sept. 1931, pp. 23-26, 2 figs. Attempt to coordinate results of prominent investigators in field, presenting in summarized form data on constants of longitudinally and transversely vibrating modes, in so far as it is accurately known.

RECEIVING APPARATUS—AUTOMATIC CONTROL. Use of Vacuum Tube Operated Relay to Control Blasting in Radio Receivers, B. Ephraim. *Radio Eng.*, vol. 11, no. 9, Sept. 1931, p. 27, 2 figs. Diagram and analysis of simple relay control system in audio circuit.

RECTIFIERS. The Design of Power Rectifier Circuits, M. McDonald. *Wireless Engr.*, vol. 8, no. 97, Oct. 1931, pp. 522-531, 8 figs. Methods of calculating effect of resistance in circuit and also effect of variation in size of tank condenser; practical examples are given.

WAVES. The Expanding Short-Wave Spectrum. *Electronics*, vol. 3, no. 3, Sept. 1931, p. 91. Compilation of known data on present and future radio channels on waves from 30,000 to 7½ cm. is given on chart.

Railroads

ELECTRIFICATION. Railway Electrification—An Alternative Proposal. *Ry. Gaz.*, vol. 55, no. 10, Sept. 4, 1931, p. 298. Finance of main-line electrification; economical alternative; scope for reduced rates; advantages of oil-electric traction.

SIGNALS—INTERLOCKING. Electric Interlocking Installed in Birmingham, Ala., L. R. Stahl. *Ry. Signaling*, vol. 24, no. 9, Sept. 1931, pp. 309-311, 7 figs. Design, construction, and operating details of 47-lever plant at crossing of three roads; simplified track and signal plan of Birmingham plant.

SUBSTATIONS. Mobile Railway Substations. *Elec. Rev.*, vol. 109, no. 2808, Sept. 18, 1931, p. 427, 3 figs. Truck-mounted mercury-vapor rectifying outfits for Italian state railways for three-phase 16 2/3-cycle system direct current at 3,000-v. contact-wire pressure for Benevento-Foggia and other lines.

TRAIN CONTROL, AUTOMATIC. Automatic Train Control on the Southern Railway. *Engineer*, vol. 152, no. 3950, Sept. 25, 1931, pp. 332-333, 8 figs. In Strowger-Hudd system permanent magnets and electromagnets are used to operate receivers carried by locomotive, which cause whistle to be blown and continuous brake to be applied as required; receivers are actuated by inductors, of which there are usually three.

Railroad Crossings

SIGNALS AND SIGNALING. Crossing Protection Signals on the Milwaukee Road. *Ry. Signaling*, vol. 24, no. 9, Sept. 1931, pp. 316-318, 9 figs. Older type of protection replaced by flashing-light type with rotating stop disk; operating conditions; plan showing location of signals in Oconomowoc; control of signals.

Rectifiers

D-C. Conversion Equipment, A. M. Garrett. *Nat. Elec. Light Assn.—Bul.*, vol. 18, no. 9, Sept. 1931, pp. 595-598, 4 figs. Report of electric machinery subcommittee of Electrical Apparatus Committee; enclosed converters; method of determining adequacy of soldered joints; new developments in conversion equipment; total number and capacity of rectifier sets installed in United States and Canada; telephone interference; high speed switching for rectifier.

Relays

Electrical *versus* Mechanical Devices Used in Control and Regulation Engineering, J. F. Shadgen. *Iron and Steel Engr.*, vol. 8, no. 9, Sept. 1931, pp. 378-382, 12 figs. Corrective devices used in art of regulation; regulating valves; regulating dampers; rheostats; solenoids; brakes and clutches; characteristics of fluid amplifying devices; characteristics of electric amplifying devices. Before Am. Iron and Steel Elec. Engrs.

Rolling Mills

ELECTRIC EQUIPMENT. Electrical Equipment of the Slabbing and Hot Strip Mills at the Wheeling Steel Corporation's Steubenville Plant, J. Farrington and H. A. Winne; *Iron and Steel Engrs.*, vol. 8, no. 7, July 1931, pp. 324-336, 16 figs. Outstanding mill installations of recent years are 45 in. reversing Universal slabbing mill and continuous hot strip mill at Steubenville, Ohio, plant of Wheeling Steel Corp.; complete electrical installation, starting with incoming 66,000 volt power lines, carrying through Ohio Power Co.'s Fort Steuben substation, Wheeling Steel Corp., outdoor substation on to 60 in. mill motor room and main auxiliary drives.

ELECTRIC DRIVE. Electric Power is Regenerated by New Roll Train Drag, A. J. Whitcomb. *Steel*, vol. 89, no. 16, Oct. 12. 1931, pp. 31-33, 5 figs. Installation combining successful regeneration of electric power with production of dragging torque which prevents back lash in sheet mill in Detroit districts; power regenerated is 540,000 kw-hr. and represents saving of $5,400 per year.

Substations

AUTOMATIC. Electricity in Limestone Mining, F. P. Brightman. *Eng. and Min. Jl.*, vol. 132, no. 5, Sept. 14, 1931, pp. 205-206, 4 figs. Details of equipment and operation at double-unit, completely automatic substation installed at Pittsburgh Limestone Co.'s Buffalo Creek mine, near Worthington, Pa., to supply direct current to mine haulage system and for general use in mining operations; synchronous motor-generator sets were selected on account of greater flexibility in control of d-c. voltage and independence of fluctuations of d-c. system voltage which affect d-c. voltage when converters are used.

DESIGN. What a Well-Built Substation May Be. *Elec. World*, vol. 98, no. 14, Oct. 3, 1931, p. 612. Zanesville (Ohio) substation of Ohio Power Co., subsidiary of American Gas & Electric Co. is representative of best and most recent of today's electrical engineering practises, and includes in its design not only features of economy, reliability, safety and ease of operation but also attractive appearance.

Switchboards

Features of Modern Switchboards, E. G. Bern. *Power Plant Eng.*, vol. 35, no. 17, Sept. 1, 1931, pp. 897-899, 4 figs. Evolution has almost extinguished resemblance between earliest and latest switchboards; unit principle of design.

Switches

Elimination of the Disconnecting Switch Hazard, J. Auchincloss. *Power Plant Eng.*, vol. 35, no. 18, Sept. 15, 1931, p. 938, 2 figs. Methods illustrating impossibility of opening disconnecting switch until oil circuit breaker has first been opened; protection afforded by magnetic lock on mechanism of disconnecting switch which is controlled by auxiliary switch on mechanism of circuit breaker.

The Minatro—A New Idea in Control Switch Design, A. J. A. Peterson. *Elec. Jl.*, vol. 28, no. 9, Sept. 1931, pp. 508-510, 6 figs. Control switch requiring only 5 sq. in. of switchboard panel space, using toggle switches for quick make and break contacts, handling 125 volts directly and that can be mounted or dismounted as unit; neat appearance; it is result of deliberate attempt to design switch for specific purpose without regard for precedent or convention.

Telephone

CIRCUITS. Four-Wire Telephone Circuits, G. C. Crawford. *Bell Laboratories Rec.*, vol. 10, no. 1, Sept. 1931, pp. 6-12, 8 figs. Advantages and characteristics of four-wire circuits; details of 44 A-1 repeaters for use in 4-wire circuits; wiring diagram of repeater.

Television

APPARATUS—OPERATION. The Practical Operation of a Complete Television System, A. B. DuMont. *Radio Eng.*, vol. 11, no. 7, July 1931, pp. 33-36, 8 figs. Technical description of Jenkins system of television now in operation.

Transformers

FOUR-WINDING. Four-Winding Transformers. *Engineer*, vol. 152, no. 3948, Sept. 11, 1931, pp. 304-305, 4 figs. Three-phase, 50-cycle transformers with four windings built by Oerlikon Co. for Ryburg-Schwoerstadt Power Supply Co., Rheinfelden, Switzerland; capacity of each of windings is 32,500 kva. while continuous overload capacity is 35,000 kva.

INSTRUMENT. A Through Type Current Transformer and Amplifier for Measuring Alternating Currents of a Few Milliamperes, W. B. Kouwenhoven. *Rev. Sci. Instruments*, vol. 2, no. 9, Sept. 1931, pp. 541-548, 2 figs. Transformers and vacuum-tube amplifiers constructed for experimental study of effects of electric shock for measurement of current actually passing through vital organs; wiring diagram and characteristics of instrument.

PARALLEL OPERATION. Balance Coil or Reactor for Paralleling Transformers, E. C. Wentz. *Elec. Jl.*, vol. 28, no. 9, Sept. 1931, pp. 526-529, 8 figs. If transformers to be paralleled are different in turns ratio, balance coil is indispensable; balance coil must also be used when secondaries of two transformers are to be paralleled, and primaries are supplied from different sources; reactors, though more limited in application, are more easily installed and have advantage of simplicity.

SPARE WINDING. Grounding Transformer Bank Supplies Station Energy. *Elec. World*, vol. 98, no. 14, Oct. 3, 1931, pp. 612-613, 2 figs. To serve as spare source of energy for station service equipment, 2,000-kva., 33,000/13,200/2,300-volt grounding transformer bank has been provided with third winding for full-capacity output of 2,300 volts at Gilbert station of Associated Gas & Electric System at Holland, N. J.; wiring diagrams are given.

Transmission Lines

HIGH TENSION—ANALYSIS. Transmission Line Analysis Indicates Ruling Tendencies, E. B. Kurtz and J. A. Douglas. *Elec. World*, vol. 98, no. 13, Sept. 26, 1931, pp. 553-555, 10 figs. Graphical determination of relations between major design values of present-day electric power transmission lines was undertaken in belief that study of large number of lines would reveal general laws governing recent design practise; analysis is based on table on "Engineering Details of Transmission Lines in United States" published by *Electrical World* in 1929, giving engineering details of 877 high-voltage transmission lines.

HIGH TENSION—INSPECTION. Methods and Procedures for Inspection of Materials Used on Overhead Lines. *Nat. Elec. Light Assn.—Pub.*, no. 150, Aug. 1931, 38 pp., 1 fig. Procedures which if followed in inspecting conductors, poles, insulators and hardware, should result in obtaining satisfactory material; methods are intended to cover more important requirements in most practical way and to indicate common-sense interpretations of various specification requirements.

HIGH TENSION—RELAYS. Theory and Application of Relay Systems, P. H. Robinson and I. T. Monseth. *Elec. Jl.*, vol. 28, no. 9, Sept. 1931, pp. 535-538, 11 figs. Relay scheme for parallel line protection is outlined; various diagrams of connection are given.

Vacuum Tubes

Patents Relating to Electronic Devices in Industry. *Electronics*, vol. 3, no. 3, Sept. 1931, pp. 92-93, 5 figs. Three patents granted by United States Patent Office are described; Langmuir patent for connecting light-sensitive cell and vacuum tube; Logan method of using light-sensitive cell for regulating flow of gas in sulphuric acid manufacture; Logan patent by which light-sensitive cell is controlling shaft revolutions; Nakken patent for combination of light-sensitive surface and triode.

ELECTROCHEMISTRY. The Electron Goes to Work in Industry, J. A. Lee. *Electrochem. Soc.—Trans.*, vol. 59, 1931, pp. 229-236, 1 fig. In electrochemical industries vacuum tube has already been adapted for several purposes and it has been suggested for many others where increased accuracy of measurements and production efficiency are important; outline of various uses for tubes and photoelectric cells.

LABORATORY USES. Electronic Tubes in the Laboratory. *Electronics*, vol. 3, no. 3, Sept. 1931, pp. 114-115, 4 figs. Symposium consisting of four short articles; Life Test for Condensers, H. W. Houck; Circuits for Light Sensitive Cells; Piezoelectric Measuring Devices, J. Lluge, H. E. Linckh, R. A. Webster, S. L. Brown and S. Harris; Vacuum Tube Control for Electric Balances, F. S. Eastman.

MEASUREMENTS. A New Method of Measuring Vacuum Tube Characteristics, J. R. Barnhart. *Radio Eng.*, vol. 11, no. 7, July 1931, pp. 30-31, 4 figs. Method of determining dynamic mutual conductance, amplification factor and plate resistance was evolved mathematically from consideration of properties of self-biased tube; equipment used consists of source of filament current, source of plate current, galvanometer and suitable resistances.

PRESSURE INDICATORS. A Cylinder Pressure Indicator, L. R. Quarles. *Elec. Jl.*, vol. 28, no. 9, Sept. 1931, p. 519, 2 figs. Newly developed grid-glow tube device for testing internal-combustion engines makes possible continuous and visible indication of pressures in cylinders.

TELEVISION. A New Modulation Tube for Television, H. F. Dalpayrat. *Radio Eng.*, vol. 11, no. 7, July 1931, p. 37, 1 fig. New mercury vapor arc tube described has very large output of modulated light and shows great possibilities.

TESTING. Vacuum Tube Life Tests, J. N. Fuller and P. W. Charton. *Radio Eng.*, vol. 11, no. 7, July 1931, pp. 21-23, 2 figs. Test conducted to determine life span of product in question, consisting in subjecting it to continuous operation simulating actual usage conditions until it wears off and becomes unsatisfactory; for vacuum tube this means until one or more of its characteristics varies beyond specified limits.

VOLTMETERS. Vacuum Tube Voltmeter of High Sensitivity, H. J. Reich, G. S. Marvin and K. A. Stoll. *Electronics*. vol. 3, no. 3, Sept. 1931, pp. 109-111, 6 figs. For larger a-c. voltages or for d-c. voltages peak type of vacuum tube voltmeter can be used, but as ordinarily constructed, using three-element tube, sensitivity is rather poor; in order to find more suitable tube, survey was made of more recent types of tubes; results of this work have made possible development of sensitive portable instrument described.

Voltage Regulators

A Non-Contact Voltage Regulator *Elec. Rev.*, vol. 109, no. 2802, Aug. 7, 1931, p. 211, 4 figs. "No contact" equipment resembles hydraulic regulator used for water turbines; apparatus acts instantaneously and produces very high operating torque.

Watthour Meters

TESTING. Manual Switching Eliminated in Rotating Standard Testing. *Elec. World*, vol. 98, no. 13, Sept. 16, 1931, p. 542, 1 fig. Great sensitivity, combined with stable operation, is claimed for vacuum tube and switch device for timing rotating standards, developed in meter department of Puget Sound Power & Light Co., according to recent report of N.E.L.A. meter committee; nervous and muscular coordination of tester do not affect test when this equipment is used.

Welding

ARC—ATOMIC HYDROGEN. Hydrogen Welding Now Automatically Controllable, S. Martin, Jr. *Elec. World*, vol. 98, no. 13, Sept. 26, 1931, p. 561, 1 fig. Welding automatically with atomic hydrogen flame presents problem of maintaining definite size of flame in fixed plane between two slowly consuming tungsten electrodes; relation of fringe of flame and work is fixed mechanically; push-button control scheme for automatic hydrogen welding, is given.

ARC—ELECTRODES. Future Development of Electrodes, T. E. Jerabek. *Welding*, vol. 2, no. 9, Sept. 1931, pp. 623-625, 3 figs. Development of thicker coatings; automatic electrodes; physical composition of electrode; possibilities of electrodes ¾ in. in diam. operating at 1,000 amp.

CHROMIUM-NICKEL STEEL. How to Weld the Chromium-Nickel Steels, S. C. Alexander. *Welding*, vol. 2, no. 8, Aug. 1931, pp. 514-517, 7 figs. Practical applications illustrate welding technique; effect of temperature on physical properties of Nirosta KA2 or "18 and 8" chromium-nickel steel based on short time test.

HOUSES, STEEL FRAME. Arc Welded Steel Residences. *Constructor*, vol. 13, no. 9, Sept. 1931, pp. 26-27, 5 figs. Features of arc welded steel frame residences in Mamaroneck, N. Y., and at Shaker Heights, Cleveland, Ohio; method of using "Battledeck" steel flooring in connection with welded steel frame residence construction; method of fastening wood sleeper to battledeck floor construction.

NICKEL. British Practise in the Welding of Monel Metal and Pure Malleable Nickel, N. C. Marples. *Am. Welding Soc.—Jl.*, vol. 10, no. 3, Mar. 1931, pp. 14-17, 6 figs. Applicability of welding methods for monel metal and pure nickel sheet, with reference to thickness; oxygen control, fluxes, use of filter rod, automatic electric seam welding.

STEEL. Analysis of Steel for Welding, W. E. Stine. *Metal Progress*, vol. 20, no. 2, Aug. 1931, pp. 91-94, 5 figs. Investigations at Lincoln Research Laboratory to determine welding characteristics for metallic arc welding with bare or washed electrodes; metallic arc welding with special electrodes; carbon arc welding with completely shielded arc; Lincoln-Stine equilibrium curve showing relation between aluminum, silicon, and manganese in carbon steels to produce best welding characteristics.

STEEL STRUCTURES. Arc Welding Joints in Steel Structures, R. W. VanKirk. *West. Machy. World*, vol. 22, no. 9, Sept. 1931, pp. 405-406, 2 figs. Development of arc welded structural joints; permissible unit stresses; advantages of electric welding; inspection.

Welders

TRAINING. Training Welders for Industrial Work, C. D. Moore. *Welding Engr.*, vol. 16, no. 7, July 1931, pp. 37-38, 4 figs. Need of practical experience of welders in addition to school training; illustrations show various conditions under which welder is required to work.

Welds

STRESSES. Stress Relieving Welded Joints, R. E. Kinkead. *Welding Engr.*, vol. 16, no. 7, July 1931, pp. 25-28, 14 figs. Nature of residual strains in steel due to temperature change; series of tests of residual stresses in welds and methods of removal.

Wheatstone Bridges

ELECTROLYTES. A Bridge for the Measurement of the Conductance of Electrolytes, P. H. Dike. *Rev. Sci. Instruments*, vol. 2, no. 7, July 1931, pp. 379-395, 4 figs. Bridge which has been designed to give higher degree of accuracy than has previously been attainable in measurements of this type, and with greater convenience of manipulation and of interpretation of results.

Industrial Notes

Unemployment Relief Plan of I-T-E Circuit Breaker Company.—It is announced that two per cent of the gross sales of the I-T-E Circuit Breaker Company, Philadelphia, for the next five months will be donated to the relief organizations of the communities in which those sales originate. A special fund of $25,000 has been deposited with the Philadelphia Trust Company from which, within ten days after receipt of each order, a check will be drawn for the relief work. No order for less than fifty dollars will be included in this relief plan. These voluntary donations all over the country will be in addition to the Company's donations for local relief. It is the hope of the I-T-E Circuit Breaker Company that other members of the electrical industry as well as of other industries, may be led to adopt this plan or a modification of it for supplying the money needed to ameliorate the condition of the nation's unemployed.

New Frequency Monitor for Broadcasting Stations.—Announcement has been made that the General Radio Company, Cambridge, Mass., has just completed development of a new frequency monitoring equipment, which will enable broadcasting stations to check their frequencies to within $\pm$ 50 cycles per second of the assigned value in accordance with the requirements of General Order No. 116 of the Federal Radio Commission. A preliminary descriptive bulletin of this equipment is available.

A New Transmission Drive.—The American Engineering Company, Philadelphia, has developed a flexible electro-hydraulic transmission, delivering any speed from zero to the maximum of the unit. One end of the transmission is connected to an electric motor or prime mover rotating at a constant speed. From the other end intermediate, smooth speeds can be obtained from maximum to stop. Among the other advantages claimed for the new development are that the direction of rotation can be changed from one direction to the opposite direction almost instantly. Controls are available to make the transmission perform a series of operations automatically. The unit is extremely compact and no gears, pulleys, chains or belts are used in construction. It is shock-proof and self-lubricating; an across-the-line starter is all that is needed for control; has a high starting torque; and it is impossible to overload the device. At the present time 5 to 15 hp. units are being manufactured.

New Motor Starter.—The Electric Controller & Manufacturing Company, of Cleveland, Ohio, announces the "No. 1 Type ZEO Across-the-line Explosion-proof Starter," which has been officially approved by the Underwriters for Class 1, Group D hazardous locations. The enclosing case is strong and tight enough to prevent the transmission of any flame that may occur within the case to surrounding atmosphere, and the flanged joint between the upper and lower parts of the case is of sufficient length to cool any gases formed within before they can come in contact with the surrounding atmosphere. The contactor mechanism and overload relays are mounted on a slate base which is removable from the case. The main contacts and overload relay contacts are oil immersed and all working parts are kept well lubricated and protected from corrosion by capillary attraction of the oil. The maximum ratings of this starter are 5 hp., 110 volts, and 10 hp., 220, 440 and 550 volts.

Agency Appointments of Meter Devices Company.—J. G. Corrin, 140 North Sycamore Avenue, Los Angeles, has been appointed sales representative in California for the Meter Devices Company, Canton, Ohio. The Wagner Peterson Corporation, 535 Clifton Street, Portland, was recently appointed to represent the Meter Devices Company in the states of Oregon and Washington.

Kearney Corporation and Chance Company Merge.—It is announced that James R. Kearney Corporation, St. Louis, has combined with the Chance Company, Centralia, Mo., manufacturers of pole anchors. The combination makes it possible to supply every type of anchor for construction requirements from a single and centrally located manufacturer. The Kearney anchors include the 4-in-1 expansion anchor, steel rod screw anchor, pipe rod screw anchor and "No-Rench" screw anchor; the Chance anchors include the 2 and 4 way expansion anchor, pyramid "cone" anchor, never-creep plate anchor and steel screw anchor.

Trade Literature

Distribution Connectors.—Bulletin 38-T. Describes distribution connectors for copper and aluminum conductors, hot line clamps and insulated sticks. Delta-Star Electric Company, 2400 Block, Fulton Street, Chicago.

Portable Instruments.—Bulletin 160, 12 pp. Describes Roller-Smith portable instruments—ammeters, voltmeters, volt-ammeters, single and polyphase wattmeters, frequency meters, power factor meters, transformers and multipliers. Roller-Smith Company, 12 Park Place, New York.

Motors.—Bulletin 210, 4 pp. Describes type "T" two-pole Reliance d-c. motors; semi-enclosed and fully-enclosed construction; pulley or sleeve bearings; in sizes up to 3 horsepower., 1,750 r.p.m. Reliance Electric & Engineering Company, Ivanhoe Road, Cleveland.

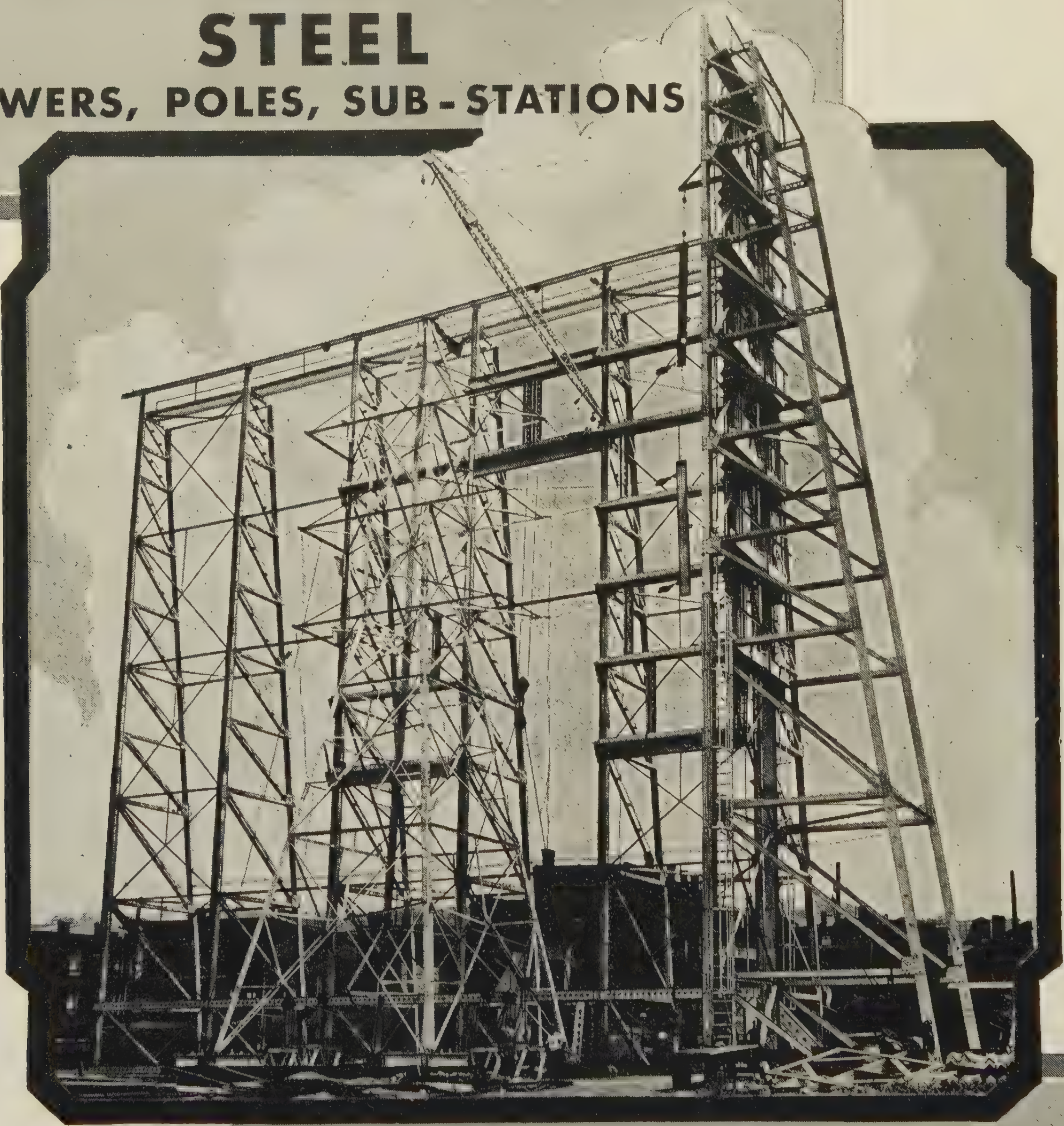
High Tension Fuses.—Bulletin 39, 8 pp. Describes Pacific Electric distribution fuse cutouts, type EM fuse supports and type EM-1 fuse switches with type EX fuse holders. Pacific Electric Manufacturing Corporation, 5815 Third Street, San Francisco, Cal.

Circuit Breakers.—Bulletin GEA-959C, 12 pp. Describes General Electric type FKR-155 oil circuit breakers, 7,500 and 15,000 volts—400 to 3,000 amperes, triple pole—single throw. This type constitutes a complete line of indoor breakers for moderate and heavy duty service. General Electric Company, Schenectady, N. Y.

Motors.—Bulletin 20516, 2 pp. Describes new, single-phase Westinghouse motors, 2 to 7½ horsepower. Because of their excellent torque characteristics these motors have extensive applications on pumps, compressors, ventilating fans, blowers, farm machinery, and wherever high starting and high accelerating torques are necessary. Westinghouse Electric & Mfg. Company, East Pittsburgh.

Asbestos Insulated Wires and Cables.—Bulletin 10-A, 30 pp. Describes Rockbestos insulated wires and cables, designed and built to withstand extremely high temperatures, oils and greases, the majority of acid fumes and vapors, etc. Specifications and descriptions are given for solid, coarse and flexible stranded cable with Rockbestos insulation from 600 to 7,500 volts; also switchboard wire, multi-conductor control cable, lead sheath control cable, locomotive cab cord, etc. Rockbestos Products Corporation, New Haven, Conn.

Circuit Testers.—Supplement, 2 pp. Describes Roller-Smith circuit testers. This low priced instrument can be used to ascertain if there is an electrical circuit existing between conductors applied to the terminals of the instrument and, secondly, it enables the user to read the resistance of the circuit under test. The HTD circuit tester is recommended by the maker for use in preference to magnetos and a-c. bell-ringing devices because of its accuracy of indications under all conditions and its lightness and compactness as well. Roller-Smith Company, 12 Park Place, New York.



more than a "good" turbine lubricant—

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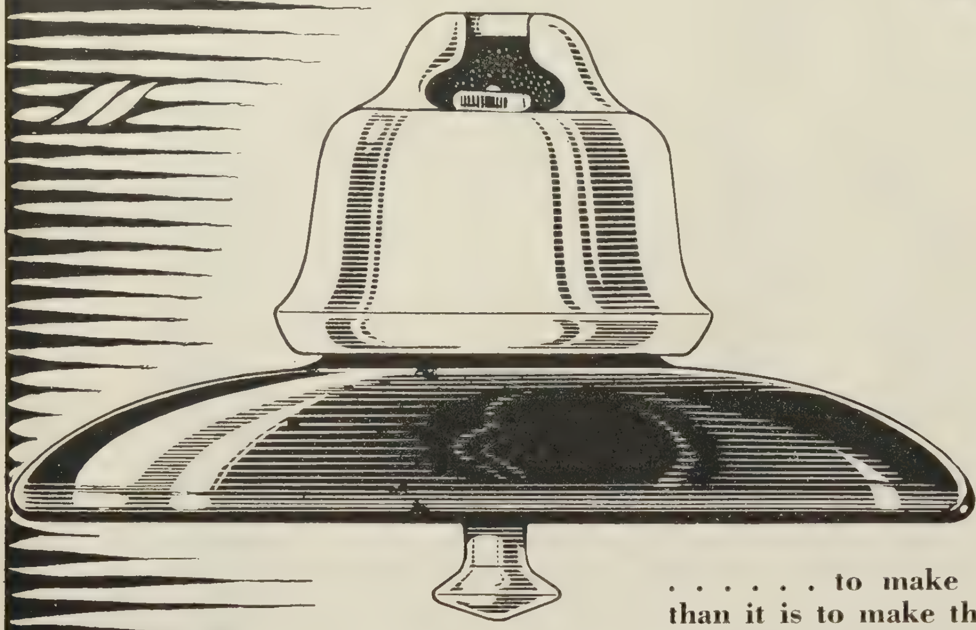

. . . . . . to make a high strength insulator than it is to make the low strength unit if the design is fundamentally right. But it can't be done overnight.

We introduced the high strength suspension insulator almost twenty years ago after convincing ourselves that the increase in strength represented no increased hazard in operation but would provide an increased safety factor and consequently greater efficiency and longer life. Thousands of these old insulators went into service under the worst possible conditions and established unblemished records.

The reason is simple. We have always been just far enough ahead of the industry's need to progress warily, testing and retesting every step. Our development has been done apart from the rush and hurry incident to demand. Our experiments have been conducted at our expense and not at yours.

Suspension insulators, regardless of strength, have failed prematurely. But those were not Locke Insulators."

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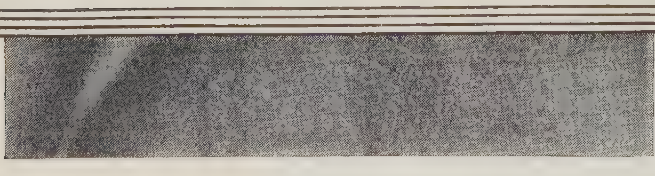
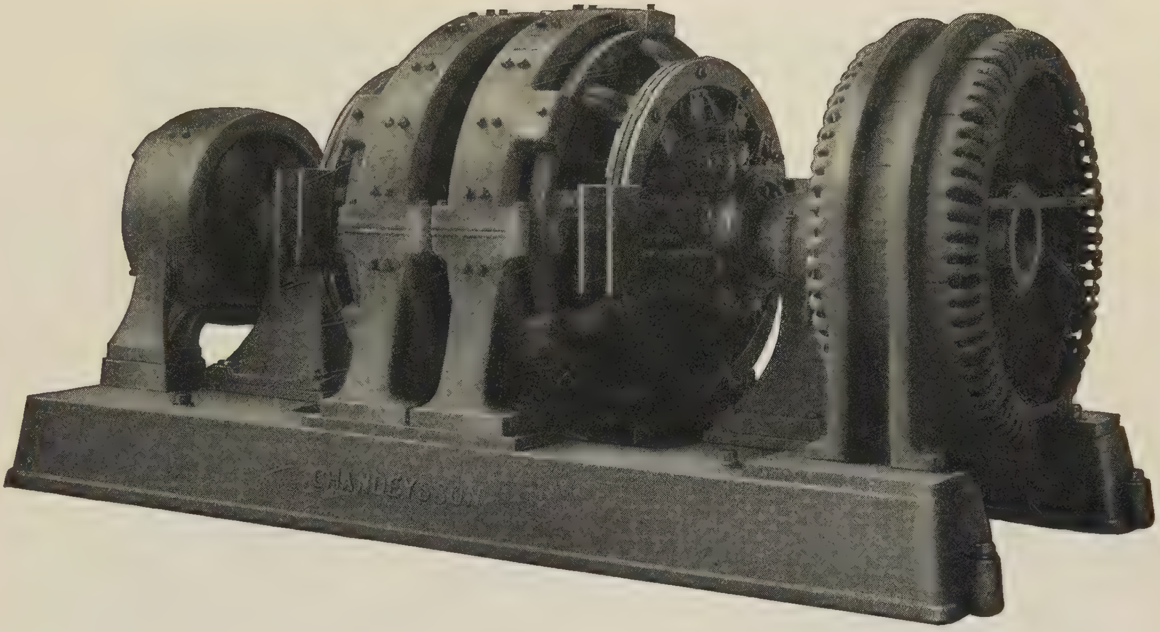
LOCKE INSULATOR CORPORATION · · · · BALTIMORE, MARYLAND




CHANDEYSSON

Which one?

One of these seven types of Wagner squirrel cage motors has just the right characteristics to operate a punch press. Which one? Another type is intended for elevator duty. Again—which one? » » » Fitting the right motor to the job is a task which should be delegated to the manufacturer, jobber or dealer specializing in motors. A misfit is costly. Squirrel cage motors, for example, are of seven types, as listed in the table reproduced from Wagner Bulletin 165. Then there are slip-ring and Fynn-Weichsel (synchronous) motors to consider. » » » And after the type of motor has been decided upon, there are many other factors to determine: horsepower, speed, mechanical design, control equipment. » » » When selecting motors, consult an authority on motors. Phone or write the nearest Wagner office, and

Table of 7 Electrical Types of Wagner Squirrel Cage Motors

Type	Standard Ratings* (Single Speed)†	Starting Current	Starting Torque**	App. Full-load Slip	Typical Applications	Consult an Authority on Motors
RP1	1/10 to 400 h. p. 3 or 2-phase 25 to 60 cycles 110 to 2200 volts	May not necessarily meet N. E. L. A. recommendations. Power companies ordinarily require current-reducing devices on ratings of 7½ h. p. and larger.	Varies with the square of the voltage applied to the motor terminals: approximately 150% of full-load torque at rated voltage; 96% at 80% voltage; as low as 38% at 50% rated voltage.	4 to 5%	Group or individual drives, in machine shops, on machine tools, fans and blowers, compressors, centrifugal pumps—on any application where normal-torque motors are satisfactory.	The selection of the right type of motor for any given application involves a thorough knowledge of horsepower, speed, current, torque, power transmission, voltage reducing devices, atmospheric conditions, rules and regulations established by power companies and insurance companies, and even laws enacted by local governments. Thus there are a multitude of factors regarding which the average motor buyer cannot keep himself informed. The selection of the right type of motor is a task which should be delegated to the manufacturer, jobber or dealer specializing in motors. When selecting motors, Wagner recommends the consultation of authorities on that subject.
RP2	7½ to 30 h. p. 3 or 2-phase 60 cycles 110 to 2200 volts	Within N. E. L. A. starting current recommendations, hence within most power companies' limitations, and therefore suitable for starting directly across the line.	Approximately same as RP1 motors. As these motors can be started across the line at rated voltage, they can start considerably more load than RP1 motors started under reduced voltage.	4 to 5%	Same as standard squirrel cage motors, type RP1.	
RP3	40 to 100 h. p. 3 or 2-phase 60 cycles 220 to 2200 volts	Within N. E. L. A. starting current recommendations, hence within most power companies' limitations, and therefore suitable for starting directly across the line.	Centrifugal pump service does not require heavy starting torque. Therefore these motors have starting torque of 80% to 100% of full-load torque.	4 to 5%	Centrifugal pumps, agitators, fans and blowers, generator sets, and other applications requiring low starting torque.	
RP4	3 to 30 h. p. 3 or 2-phase 60 cycles 110 to 2200 volts	Within N. E. L. A. starting current recommendations, hence within most power companies' limitations, and therefore suitable for starting directly across the line.	About 200% to 250% of full-load torque.	4 to 5%	Crushers, plunger pumps, belt conveyors starting under load, large air compressors, large refrigerating machinery, mixers, and other applications requiring high starting torque.	
RP5	40 to 100 h. p. 3 or 2-phase 60 cycles 220 to 2200 volts	These motors have starting currents above most power companies' limitations; hence, current reducing starting devices ordinarily used.	Varies with the square of the voltage applied to the motor terminals: approximately 200% to 250% of full-load torque at rated voltage; 130% to 160% at 80% voltage; 85% to 106% at 65% rated voltage.	4 to 5%	The logical motor to use for applications where the torque produced by RP1 motors is not sufficient. If the starting torque of type RP5 motors under reduced voltage is too low for any application, Wagner slip-ring or Fynn-Weichsel motors should be used.	
RP6	1 to 150 h. p. 3 or 2-phase 25 to 60 cycles 110 to 2200 volts	Low enough to start across the line.	About 350% of full-load torque.	10 to 13%	Punch presses, shears, bulldozers, metal drawing operations, balers and other machinery equipped with flywheels or having flywheel effect.	
RP7	1 to 30 h. p. 3 or 2-phase 25 to 60 cycles 110 to 550 volts	Lower than any other type of squirrel cage motor. No current reducing starting devices used.	Approximately 250% of full-load torque.	15 to 17%	Elevators, cranes, hoists, dumbwaiters.	

*In addition to ratings listed, Wagner builds special frequency and special voltage motors as special apparatus.
†These seven types are also available in 2, 3 or 4 speeds.
**All percentages given are for 4-pole 60-cycle motors only.

let a Wagner sales-engineer select from among Wagner's 25,000 type-hp-rpm combinations the right motor for each application. » » » » » » » »

Additional copies of the above table will be gladly sent you. Just fill out and sign the coupon. The table is reproduced from the 24-page Bulletin 165 on the subject of squirrel cage motors. Ask for a copy of the bulletin, too.

WAGNER ELECTRIC CORPORATION
6400 Plymouth Ave., St. Louis, Mo.

Please send..............copies of the squirrel cage motor table.

If you desire a copy of Bulletin 165 place an "X" here ☐

Name and Position ....

Company ....

Address .... L231-6 XA

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Electric Corporation
6400 Plymouth Ave., St. Louis, U. S. A.
Motors Transformers Fans
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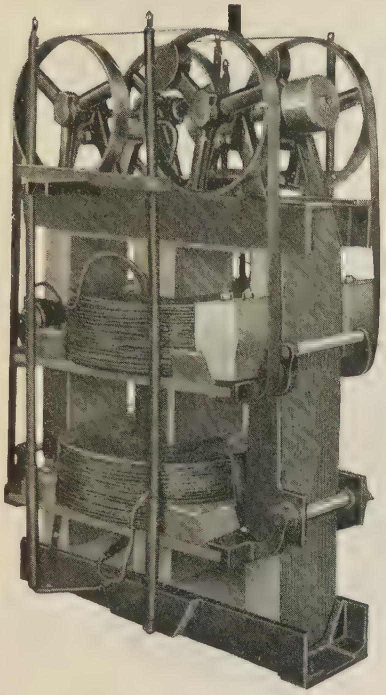

Manufactured in all standard sizes from 3 to 30 KVA for both pole and subway use. Bulletin 3110 which describes this unit more fully will be mailed upon request.

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MOLONEY Engineers have developed and perfected a new Constant Current Street Lighting Transformer. This transformer has the unique arrangement whereby both primary and secondary coils move through a small angle: thus giving better regulation and a higher power factor. This new unit has many superior operating characteristics; it is quiet in operation, low in maintenance cost and has higher operating efficiencies.

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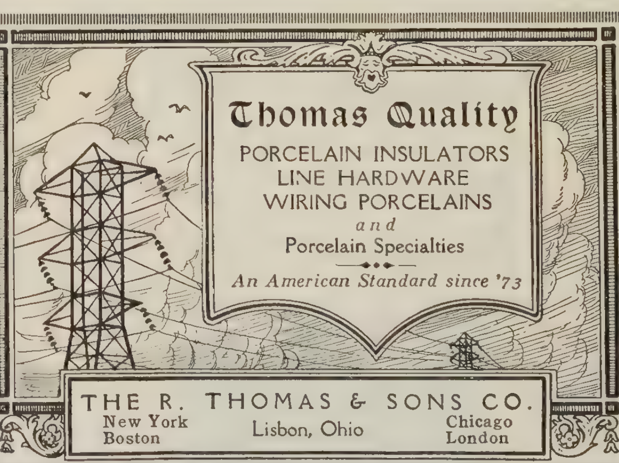

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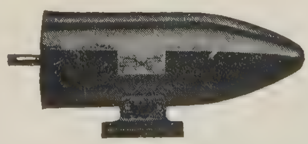

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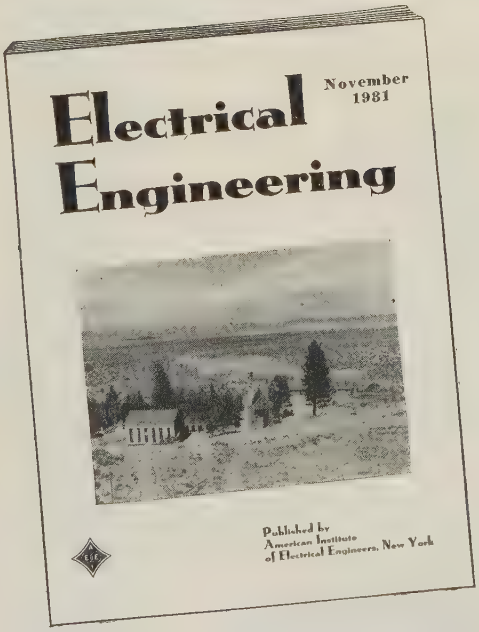
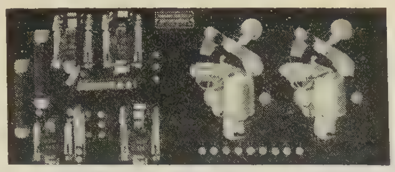


The cost complete will not exceed $3.00 and may be lower than that figure depending upon such economies as can be further effected. Full details and an order form will appear in the January 1932 issue of ELECTRICAL ENGINEERING.

Now You May Have Your 1931 Copies Bound in One Volume

FOR the convenience of those wishing to preserve their copies of ELECTRICAL ENGINEERING for the year 1931, the Institute is arranging with its bindery to perform this service.

The proposed service involves (1) the shipping to the Order Department, A.I.E.E., 33 West 39th Street, New York, of the twelve issues of Vol. 50, (1931), shipping charges prepaid by the sender; (2) the binding of these twelve issues into one volume, neatly and durably, in a style similar to that now employed for the cloth bound TRANSACTIONS; (3) the return shipment prepaid of this bound volume.



Magnetic relays with time-delay feature designed for remote control of radio telegraph station.

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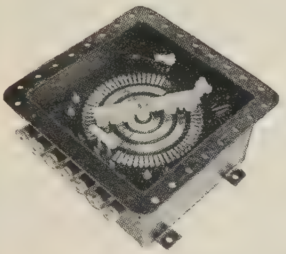

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THE design of electric control equipment for special applications requires the ability of experienced engineers.

Metallurgists know that products fail more often because of faulty design than because of faulty material.

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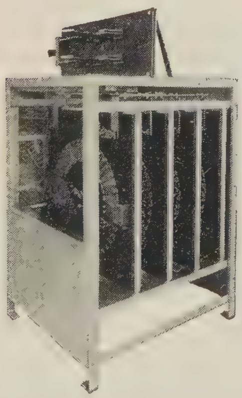
Take advantage of our years of experience in the design of control equipment to meet unusual conditions. May we do for you what we have done for many others?



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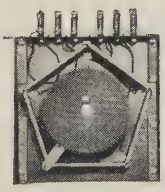
WRITE US ABOUT YOUR PARTICULAR PROBLEM



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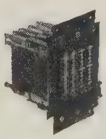

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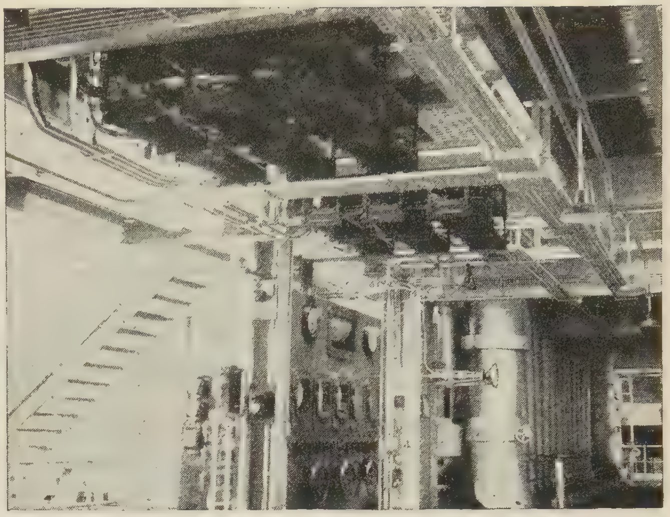

Circuit Layouts Made Easier

THERE is always a certain amount of doubt as to the immunity of lighting, control and power circuits from insulation failure due to severe operating conditions.

Particularly is this true in the steam side of central stations and in certain sections of industrial plants where wiring is exposed to the attack of heat and moisture, oil, grease, fumes or fire hazard.

Naturally modern practice in circuit layout seeks to remove wiring from these areas, but this is never entirely successful as any plant electrician will testify.

How much better practice to use wires so insulated that they are not affected by these deteriorating conditions, even if they are exposed to them.

Rockbestos wires and cables are basically insulated with asbestos, placed on the wire in the form of a felted wall, thoroughly impregnated with special inert insulating compounds, by the ROCKBESTOS Process. To such a wire, insulated with a material millions of years old in its present form, a hundred years of troublefree service in the conduits of a central station is to its span of life about as a drop of water to Niagara.

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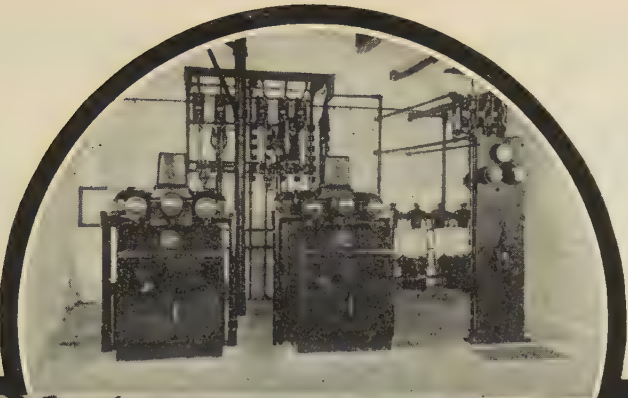

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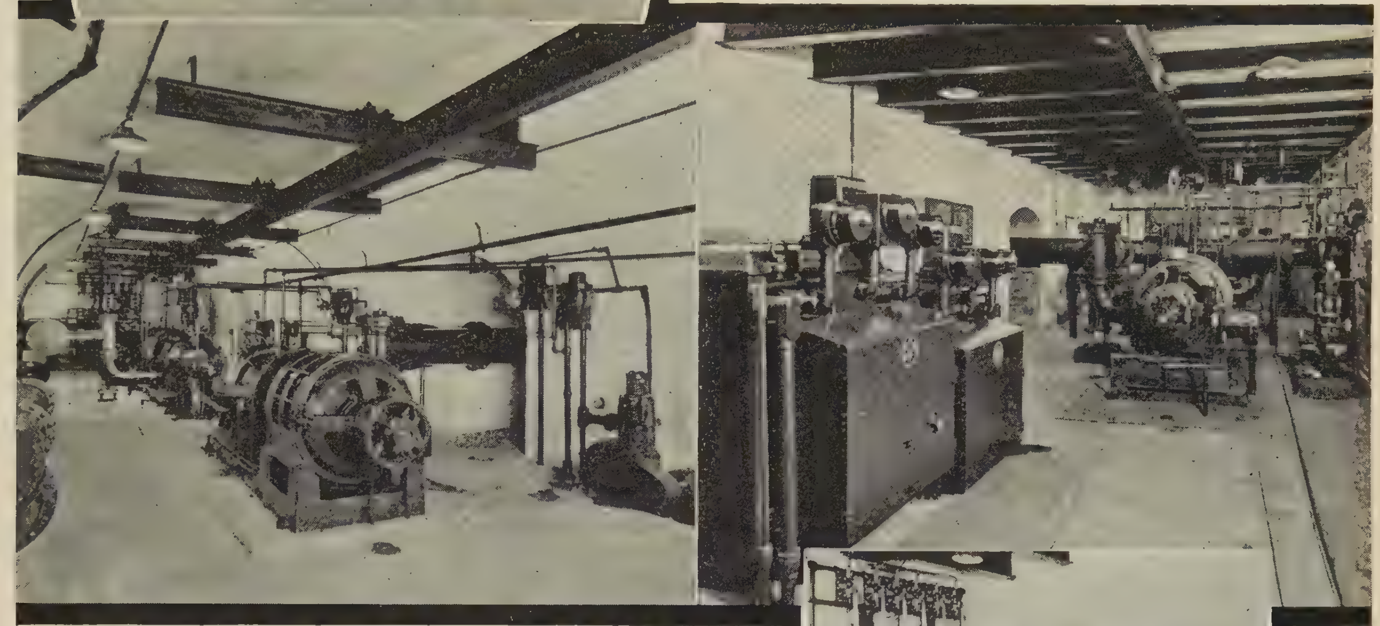

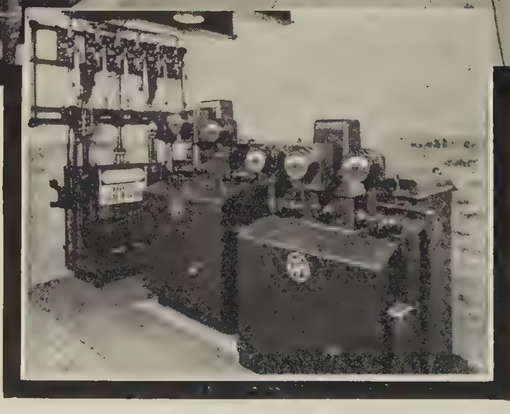

These reliable units make a good-looking job in any pumping station

Motor starters form a very important part in the successful operation of the pumping station whether the motor-driven unit is automatically controlled or started and stopped manually by a push button.

Illustrated above are two installations, typical of the many hundreds of pumping stations equipped with EC&M Automatic Motor Starters. These indicate the manner in which EC&M builds this important link in pumping stations.

Bulletins 1042-G, 1047-AJ and 1100-A show many other interesting installations of EC&M Motor Starters and illustrate the features that make them reliable for this important service. Write for your copies.

Cost Less to Install and Are Moisture Proof—

Since EC&M Starters are completely wired, self-contained units, they are easily and quickly installed. The oil-immersed feature insures they are always well lubricated—protected from corrosion. Being totally enclosed, they are also shock-proof. Ask about them.

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CHICAGO-CONWAY BLDG.
DETROIT-DIME BANK BLDG.
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CINCINNATI-1ST NATIONAL BANK BLDG.
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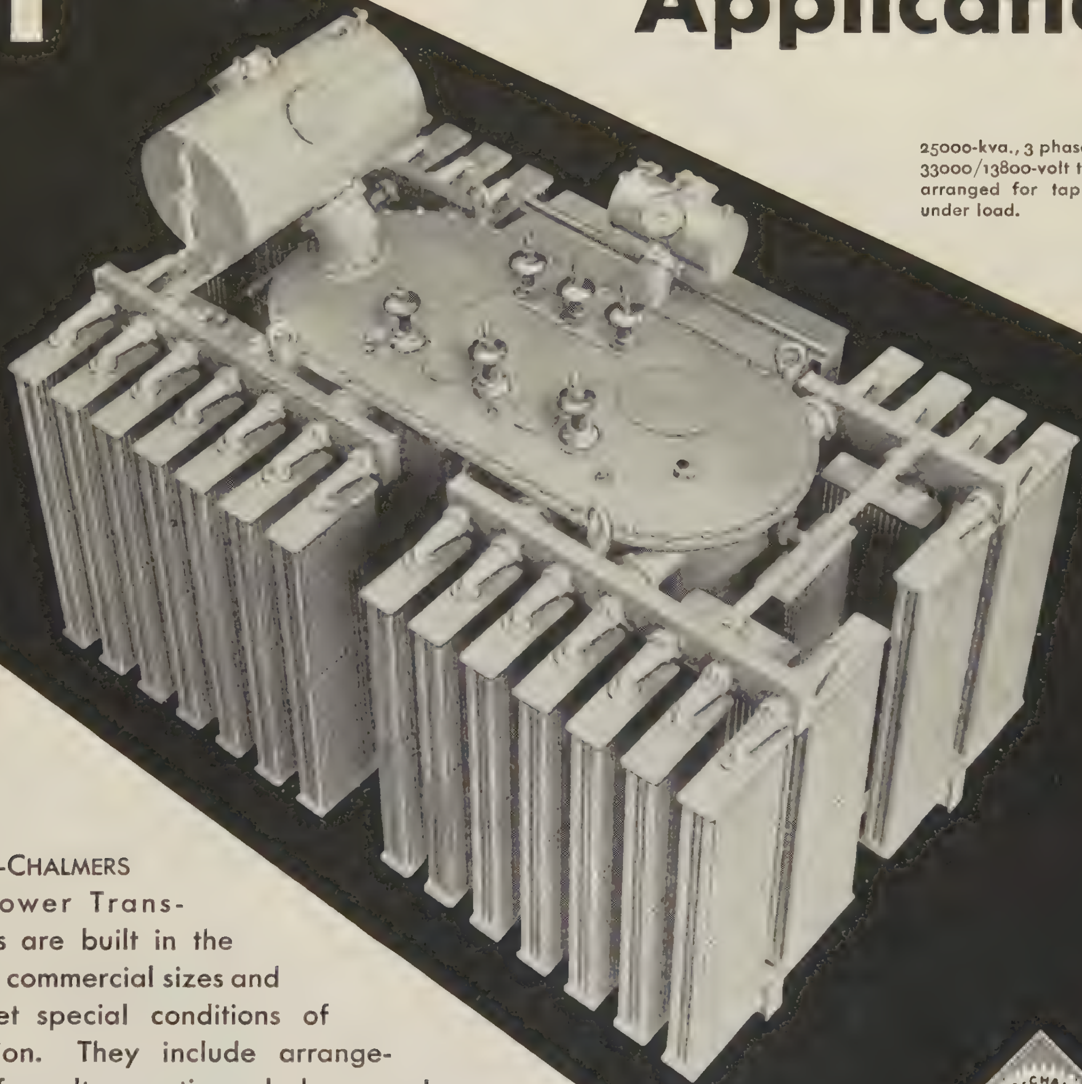
HOUSTON-P.O. BOX 4182
TORONTO-REFORD BLDG.

PHILADELPHIA-WITHERSPOON BLDG.
PITTSBURGH-OLIVER BLDG.
SAN FRANCISCO-CALL BUILDING
MONTREAL-CASTLE BLDG.
BUFFALO-888 COLVIN BLVD.
SEATTLE-2207-1ST AVE. SO.

Index to Advertised Products—*Continued*

Transformers for Every Application



25000-kva., 3 phase, 60 cycle, 33000/13800-volt transformer arranged for tap changing under load.

Allis-Chalmers Power Transformers are built in the largest commercial sizes and to meet special conditions of operation. They include arrangements for voltage ratio and phase angle control under load, special and unusual terminal compartments, and unusual shipping arrangements. . . . The complete Allis-Chalmers transformer line includes distribution, subway and network types, instrument and metering transformers, and outdoor metering outfits.

A-C ALLIS-CHALMERS MILWAUKEE

ALLIS-CHALMERS

Allis-Chalmers Manufacturing Company, Milwaukee

Index to Advertised Products—*Continued*

SUB-STATIONS
American Bridge Co., New York
General Electric Co., Schenectady
Railway & Ind. Engg. Co., Greensburg, Pa.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

SWITCHBOARDS
Allis-Chalmers Mfg. Co., Milwaukee
Bull Dog Electric Products Co., Detroit
Condit Electrical Mfg. Corp., Boston
General Electric Co., Schenectady
Metropolitan Device Corp., Brooklyn, N. Y.
Roller-Smith Co., New York
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

SWITCHES

Automatic Time
General Electric Co., Schenectady
Minerallac Electric Co., Chicago
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

Disconnecting
Bull Dog Electric Products Co., Detroit
Condit Electrical Mfg. Corp., Boston
General Electric Co., Schenectady
Kearney Corp., Jas. R., St. Louis
Railway & Ind. Engg. Co., Greensburg, Pa.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

Fuse
Bull Dog Electric Products Co., Detroit
General Electric Co., Schenectady
Kearney Corp., Jas. R., St. Louis
Metropolitan Device Corp., Brooklyn, N. Y.

Knife
Electric Controller & Mfg. Co., Cleveland
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

Magnetic
Electric Controller & Mfg. Co., Cleveland
Ward Leonard Electric Co., Mt. Vernon, N. Y.

Oil
Condit Electrical Mfg. Corp., Boston
General Electric Co., Schenectady
Roller-Smith Co., New York
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

Remote Control
Automatic Electric, Inc., Chicago
Condit Electrical Mfg. Corp., Boston
General Electric Co., Schenectady
Roller-Smith Co., New York
Rowan Controller Co., Baltimore, Md.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

TELEPHONE CONNECTORS
Kearney Corp., Jas. R., St. Louis

TELEPHONE & SIGNALING SYSTEMS
Automatic Electric, Inc., Chicago

TESTING SETS, HIGH VOLTAGE
American Transformer Co., Newark, N. J.
General Electric Co., Schenectady

TOWERS, TRANSMISSION
American Bridge Co., New York

TRANSFORMERS
Allis-Chalmers Mfg. Co., Milwaukee
American Transformer Co., Newark, N. J.
Chicago Transformer Corp., Chicago
Ferranti, Ltd., Hollinwood, England
Ferranti, Inc., New York
Ferranti Electric, Ltd., Toronto, Ont.
General Electric Co., Schenectady
Kuhlman Electric Co., Bay City, Mich.
Moloney Electric Co., St. Louis
Sangamo Electric Company, Springfield, Ill.
Wagner Electric Corp., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

Factory
American Transformer Co., Newark, N. J.
Kuhlman Electric Co., Bay City, Mich.
Moloney Electric Co., St. Louis, Mo.
Wagner Electric Corp., St. Louis

Furnace
Allis-Chalmers Mfg. Co., Milwaukee
American Transformer Co., Newark, N. J.
Moloney Electric Co., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

TRANSFORMERS—*Continued*

Metering
American Transformer Co., Newark, N. J.
Ferranti, Ltd., Hollinwood, England
Ferranti, Inc., New York
Ferranti Electric, Ltd., Toronto, Ont.
Roller-Smith Co., New York
Sangamo Electric Company, Springfield, Ill.
Weston Elec. Inst. Corp., Newark, N. J.

Radio
American Transformer Co., Newark, N. J.
Chicago Transformer Corp., Chicago
Ferranti, Ltd., Hollinwood, England
Ferranti, Inc., New York
Ferranti Electric, Ltd., Toronto, Ont.
Sangamo Electric Company, Springfield, Ill.

Street Lighting
Kuhlman Electric Co., Bay City, Mich.

TROLLEY LINE MATERIALS
General Electric Co., Schenectady
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

TURBINE GENERATORS
Allis-Chalmers Mfg. Co., Milwaukee
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

TURBINES, HYDRAULIC
Allis-Chalmers Mfg. Co., Milwaukee

TURBINES, STEAM
Allis-Chalmers Mfg. Co., Milwaukee
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

TURBO-GENERATORS
Allis-Chalmers Mfg. Co., Milwaukee
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

VALVES, BRASS

Gas, Water, Steam
Ohio Brass Co., Mansfield, O.

VARNISHES, INSULATING
General Electric Co., Bridgeport, Conn.
Irvington Varnish & Insulator Co., Irvington, N. J.
Mica Insulator Co., New York
Minerallac Electric Co., Chicago
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

WELDING MACHINES, ELECTRIC
American Transformer Co., Newark, N. J.
General Electric Co., Schenectady
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

WELDING WIRES & RODS
American Steel & Wire Co., Chicago
Ohio Brass Co., Mansfield, O.

WIRES AND CABLES

Armored Cable
American Steel & Wire Co., Chicago
General Cable Corporation, New York
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Western Electric Co., All Principal Cities

Asbestos Covered
American Steel & Wire Co., Chicago
General Electric Co., Schenectady
Rockbestos Products Corp., New Haven, Conn.

Asbestos, Varnished Cambric
Rockbestos Products Corp., New Haven, Conn.

Automotive
American Steel & Wire Co., Chicago
General Cable Corporation, New York
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Western Electric Co., All Principal Cities

WIRES AND CABLES—*Continued*

Bare Copper
American Steel & Wire Co., Chicago
General Cable Corporation, New York
Roebling's Sons Co., John A., Trenton, N. J.
Western Electric Co., All Principal Cities

Copper Clad
American Steel & Wire Co., Chicago
Western Electric Co., All Principal Cities

Copperweld
Copperweld Steel Co., Glassport, Pa.
General Cable Corporation, New York

Fleixble Cord
American Steel & Wire Co., Chicago
General Cable Corporation, New York
General Electric Co., Schenectady
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston

Flexible Cord, (Heater) Asbestos Insulated
Rockbestos Products Corp., New Haven, Conn.

Heavy Duty Cord
American Steel & Wire Co., Chicago
General Cable Corporation, New York
Okonite Company, The, Passaic, N. J.
Simplex Wire & Cable Co., Boston

Fuse
American Steel & Wire Co., Chicago
General Electric Co., Schenectady
Roebling's Sons Co., John A., Trenton, N. J.

Lead Covered (Paper and Varnished Cambric Insulated)
American Steel & Wire Co., Chicago
General Cable Corporation, New York
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
Okonite Company, The, Passaic, N. J.
Okonite-Callender Cable Co., The, Inc., Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Western Electric Co., All Principal Cities

Leads, Asbestos Insulated
Rockbestos Products Corp., New Haven, Conn.

Magnet
American Steel & Wire Co., Chicago
General Cable Corporation, New York
General Electric Co., Schenectady
Roebling's Sons Co., John A., Trenton, N. J.
Western Electric Co., All Principal Cities

Magnet, Asbestos Insulated
Rockbestos Products Corp., New Haven, Conn.

Rubber Insulated
American Steel & Wire Co., Chicago
General Cable Corporation, New York
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Western Electric Co., All Principal Cities

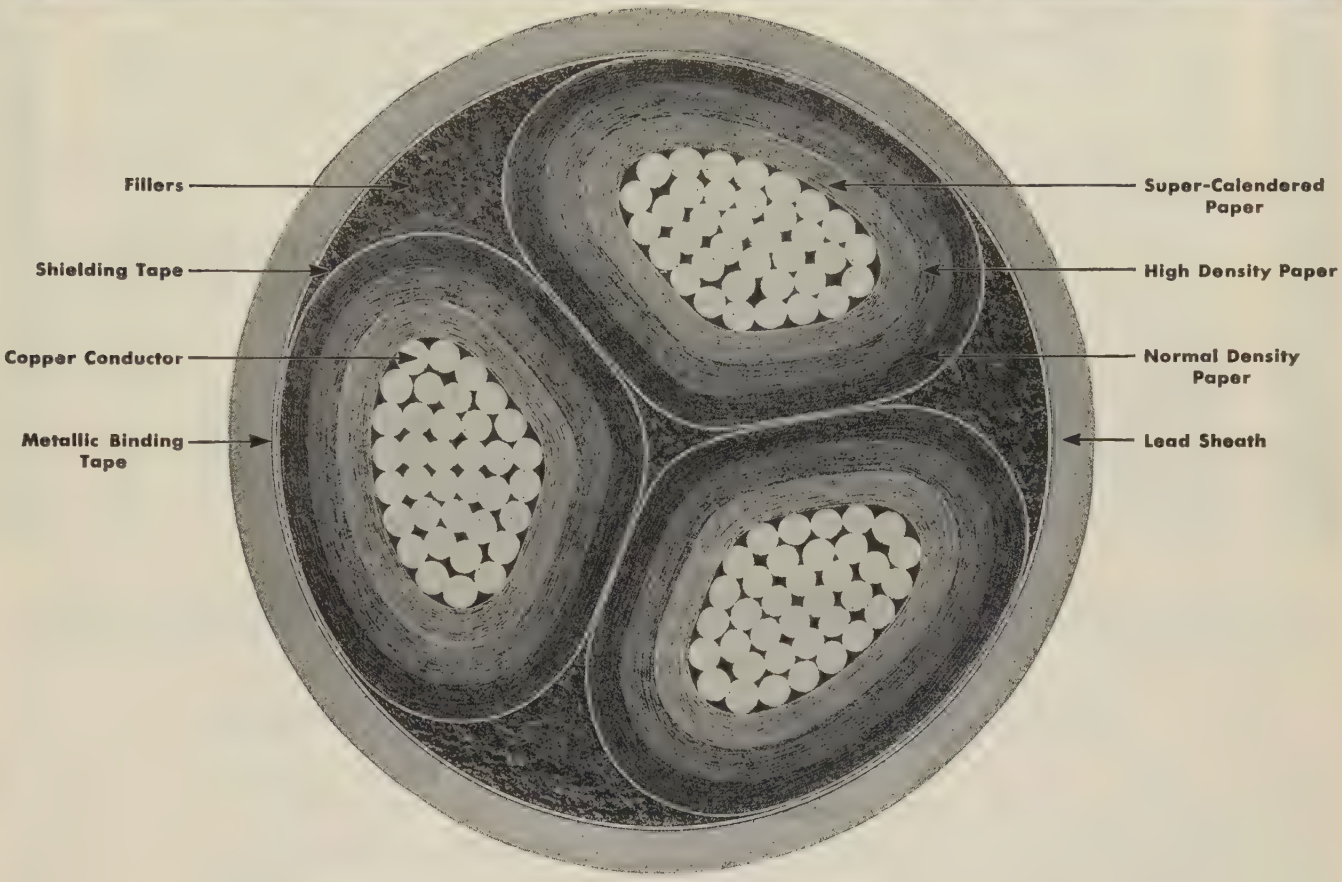
Switchboard, Asbestos Insulated
Rockbestos Products Corp., New Haven, Conn.

Tree Wire
American Steel & Wire Co., Chicago
General Cable Corporation, New York
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston

Trolley
American Steel & Wire Co., Chicago
Copperweld Steel Co., Glassport, Pa.
General Cable Corporation, New York
Roebling's Sons Co., John A., Trenton, N. J.
Western Electric Co., All Principal Cities

Weatherproof
American Steel & Wire Co., Chicago
Copperweld Steel Co., Glassport, Pa.
General Cable Corporation, New York
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Western Electric Co., All Principal Cities

GENERAL CABLE TYPE H POWER CABLE IS INSULATED WITH GRADED PAPER



General Cable Type "H" is insulated with super-calendered and graded paper. There are many sound engineering reasons for the use of super-calendered and graded paper in the manufacture of General Cable Type H Power Cable. Among these the following are outstanding:

1. Super-calendered paper has approximately 15% higher dielectric strength than normal density paper.
2. Super-calendered paper has approximately 30% higher mechanical strength than normal density paper.
3. Super-calendered paper has approximately 15 to 25% higher surge breakdown than normal density paper.
4. The ratio of oil to paper is less with super-calendered paper than with low density paper. As the expansion of oil with temperature is largely responsible for void formation this means that there is less tendency to form voids in a cable when super-calendered paper is used.

Super-calendered and Graded paper insulation, offers greater reliability not only during normal operation, but also during abnormal conditions incident to switching surges, arcing grounds or lightning. . . Further data can be obtained from our nearest office.

GENERAL CABLE CORPORATION

EXECUTIVE OFFICES: 420 LEXINGTON AVENUE, NEW YORK CITY

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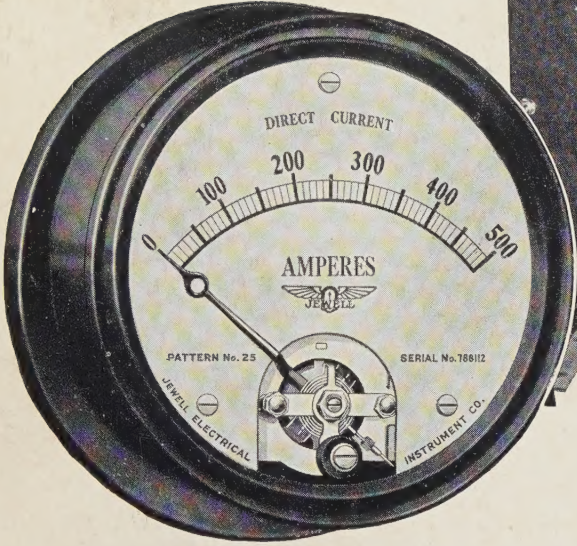

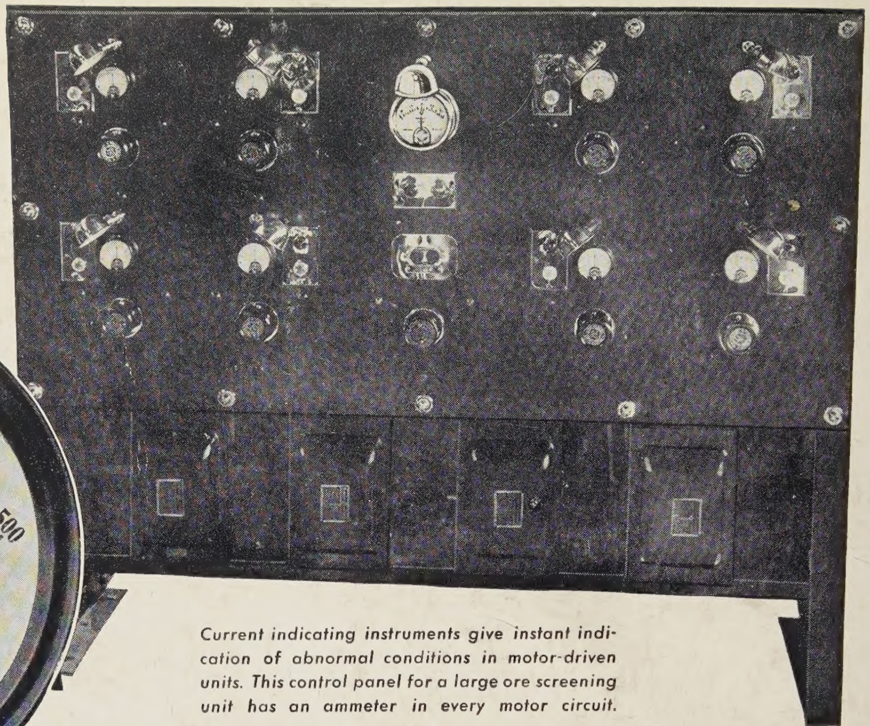

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